TF 2400

EJ 2032

TF 2400

10—110 Mc/s Converter

INSTRUCTION MANUAL

MP MASTER
MA23664

MARCONI INSTRUMENTS LIMITED

OPERATING INSTRUCTIONS

No. EB 2400

for

10—110 Mc/s Converter

TF 2400 & TF 2400R

(For the 10-500 Mc/s Converter, TF 2400/1, use this handbook in conjunction with the handbook for TM 7164)

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MARCONI INSTRUMENTS LIMITED
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7/66/E

EB 2400
1d - 7/66

CONTENTS

1 GENERAL INFORMATION

1.1	Introduction	3
1.2	Data Summary	4

2 OPERATION

2.1	Installation	6
2.2	Controls and Connectors	6
2.3	Preliminaries	6
2.4	Video	7
2.5	Untuned	8
2.6	Tuned	10
2.7	Wavemeter	12

3 DESIGN DETAILS AND MAINTENANCE

3.1	General	13
3.2	Removing the Converter Unit	13
3.3	Power Supply	14
3.4	Video Amplifier and Schmitt Trigger	17
3.5	Balanced Mixer	20
3.6	High Frequency Suppression Circuit	22
3.7	1-10 Mc/s Multiplier	23
3.8	Harmonic Selector	26
3.9	Wavemeter	28

LIST OF REPLACEABLE PARTS 30

INTERCONNECTING DIAGRAM ... ... inside back cover

I GENERAL INFORMATION

1.1 INTRODUCTION

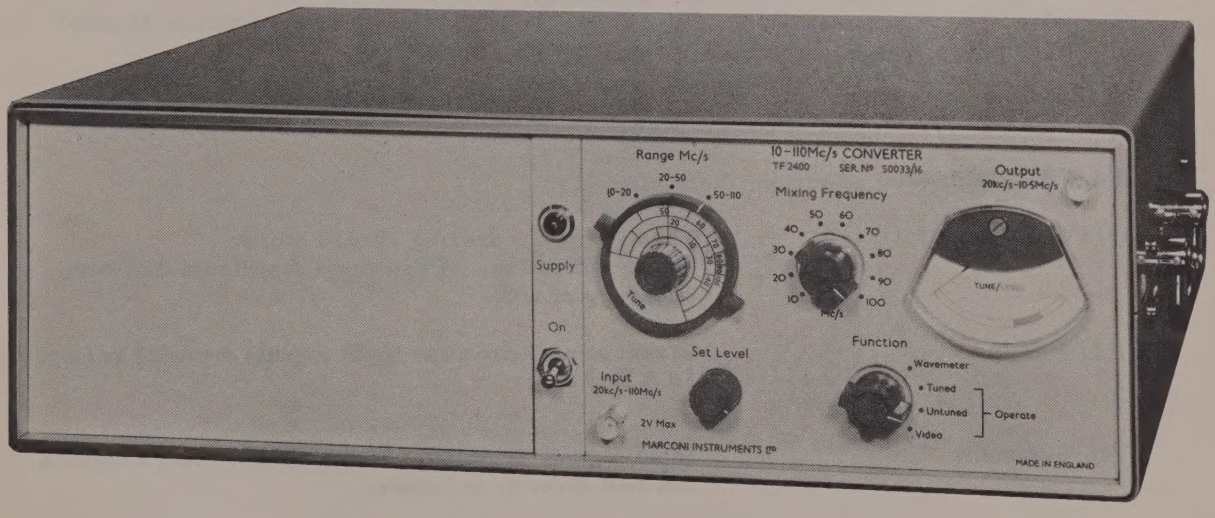
The 10-110 Mc/s Converter, TF 2400 is a frequency converter designed to extend the range of 10 Mc/s Counter/Frequency Meters, such as the M.I. TF 1417, to 110 Mc/s.

A wavemeter is incorporated so that an approximate indication of an unknown input frequency may be obtained. Provision is also made to tune input signals containing unwanted frequencies. An input attenuator controls the voltage level and a meter indicates when there is sufficient output from the Converter to correctly drive a counter. Input signals below 10 Mc/s are amplified and passed directly to the counter for measurement.

The blank panel which covers the left-hand section of the instrument may be replaced by the 100-500 Mc/s Converter, TM 7164. This unit is an optional accessory which, when used in conjunction with TF 2400 extends the counter range to 510 Mc/s.

The general principle of operation of the instrument is that input signals above 10 Mc/s are mixed with a harmonic of 10 Mc/s, produced from a 1 Mc/s standard frequency signal. This harmonic is selected so that the resultant difference frequency is below 10 Mc/s and can be measured by the counter.

A rack mounting version of the instrument is also available.



1.2 DATA SUMMARY

INPUT FREQUENCY RANGE :	As converter; 10.1 Mc/s to 110.5 Mc/s. As amplifier; 20 kc/s to 10.5 Mc/s. (Fixed output, 2 V rectangular.)
ACCURACY :	±1 count ±standard frequency accuracy (with standard frequency drive from counter).
INPUT VOLTAGE RANGE :	10 mV r.m.s. minimum. 2 V r.m.s. maximum. Level set by continuously variable attenuator. Meter indication of correct level setting.
INPUT IMPEDANCE :	Low impedance. Dependent on attenuator setting. In general about 50 Ω.
OUTPUT FREQUENCY RANGE :	20 kc/s to 10.5 Mc/s.
OUTPUT VOLTAGE :	2 V rectangular $\pm\frac{1}{2}$ V.
OUTPUT IMPEDANCE :	100 Ω in series with 0.1 μF approximately.

STANDARD FREQUENCY INPUT

Frequency :	1 Mc/s.
Level :	250 mV to 5 V r.m.s.
Input Impedance :	a) TF 2400 only; 4 kΩ minimum shunted by 60 pF maximum. b) TF 2400 with TM 7164; 2 kΩ minimum shunted by 120 pF maximum.

FUNCTION SELECTION

(a) Wavemeter :	Three ranges covering 10-110 Mc/s. Meter indication. Frequency read from dial with accuracy of ±3%.
(b) Video :	Direct amplification of input signals from 20 kc/s to 10.5 Mc/s.
(c) Untuned :	Input signal, from 10.1 Mc/s to 110.5 Mc/s applied untuned directly to mixer.
(d) Tuned :	Input signal, from 10.1 Mc/s to 110.5 Mc/s, applied to mixer via three range tuned pre-selector.

POWER REQUIREMENTS :

190 to 260 V and 95 to 130 V, 40 to 500 c/s.
Power consumption TF 2400 only : $3\frac{1}{2}$ W.
TF 2400 with TM 7164 : 5 W.

DIMENSIONS :
(over projections)

Height	Width	Depth
6 in	18 1/4 in	14 in
(15.2 cm)	(46.4 cm)	(35.6 cm)

(10-110 Mc/s Converter uses half total panel width. The blank section may be removed to accommodate the 100-500 Mc/s Converter.)

WEIGHT :

16 lb (7.3 kg).
with TM 7164 : $18\frac{1}{2}$ lb (8.4 kg).

ACCESSORIES SUPPLIED :

Lead to counter (front) TM 4726/212.
Low capacitance lead from counter (rear) TM 4726/207.
One coaxial free plug, Type B.N.C.

ACCESSORIES AVAILABLE :

100-500 Mc/s Converter Type TM 7164. (This fits in place of the blank panel section of the TF 2400.)
Supplied with jumper lead to connect to TF 2400.

INPUT FREQUENCY RANGE : As converter : 100.5 to 510.5 Mc/s. Straight through via 50 Ω variable attenuator : Up to 110.5 Mc/s.

INPUT VOLTAGE RANGE : 100 mV r.m.s. minimum into 50 Ω; 2 V r.m.s. maximum. Attenuator set by meter indication of basic TF 2400.

INPUT IMPEDANCE : Low impedance. Dependent on attenuator setting. In general about 50 Ω.

OUTPUT FREQUENCY : 500 kc/s to 110.5 Mc/s.

STANDARD FREQUENCY INPUT :
Frequency : 1 Mc/s.
Level : 250 mV to 5 V r.m.s.
Input Impedance : 4 kΩ minimum in parallel with 60 pF maximum. This input is obtained by an internal connection from the TF 2400.

POWER REQUIREMENT :
+7 V stabilized)
-15 V stabilized) normally supplied by TF 2400.
-40 V stabilized)

WEIGHT : 3 lb (1.4 kg).

2 OPERATION

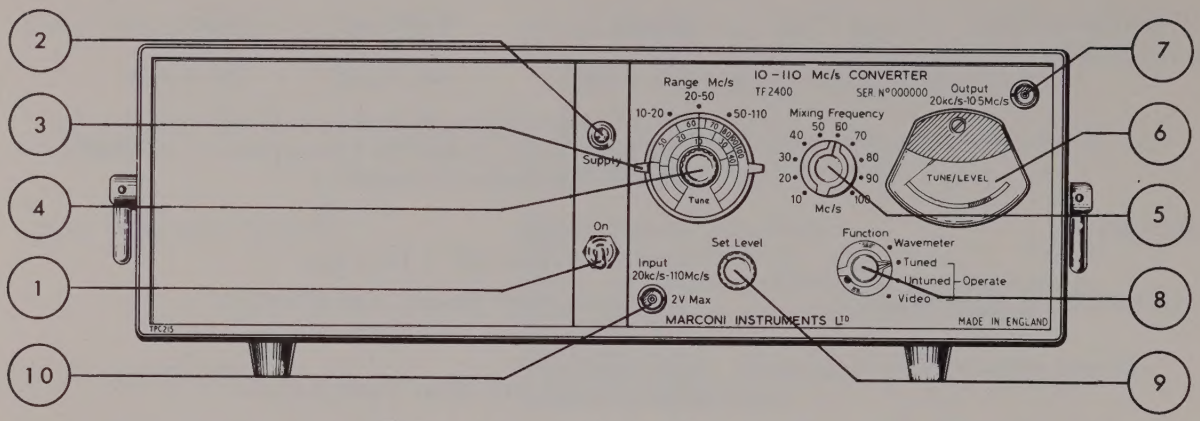


Fig. 2.1 Controls and Connectors

2.1 INSTALLATION

The mains lead is a free cable fitted at one end with a female plug which connects with the instrument. When fitting a suitable mains plug, note that the earth (or chassis) conductor has a yellow designation sleeve with a green circuit earth symbol, the neutral conductor has a black sleeve with a white 'N' and the line (or phase) conductor has no sleeve.

Before connecting the instrument to the power supply, check that the input tapping and the fuse rating are correct for the supply voltage available.

2.2 CONTROLS AND CONNECTORS

(1) SUPPLY switch.

(2) PILOT LAMP

(3) RANGE Mc/s switch. Selects frequency band in which input signal lies. Operative only when FUNCTION switch is in 'Tuned' or 'Wavemeter' positions.

(4) TUNE control/dial. Used in conjunction with RANGE Mc/s switch for tuning input signals, and finding approximate frequency of unknown signals.

(5) MIXING FREQUENCY switch. Selects a harmonic to mix with unknown signal.

(6) METER. Used in tuning, or finding approximate frequency of input signals, and indicates when there is sufficient voltage level to drive the counter.

(7) OUTPUT socket. Connect to counter input.

(8) FUNCTION switch. Determines which operation the instrument performs.

(9) SET LEVEL control. Controls voltage level to instrument by adjusting the continuously variable input attenuator.

(10) INPUT socket. Connect to unknown signal.

The following are located on the rear panel of the instrument :

1 Mc/s INPUT. Connect to 1 Mc/s standard frequency output of counter.

SUPPLY socket.

FUSE. 230 V-100 mA; 115 V-250 mA.

2.3 PRELIMINARIES

CONNECT THE 1 Mc/s STANDARD FREQUENCY DRIVE from the counter to the socket on the rear panel, by means of the low capacitance cable supplied with the Converter.

Connect the OUTPUT socket to the TF 1417 Counter INPUT A socket. Set the Counter to measure frequency on the FREQ A position.

2.4 VIDEO

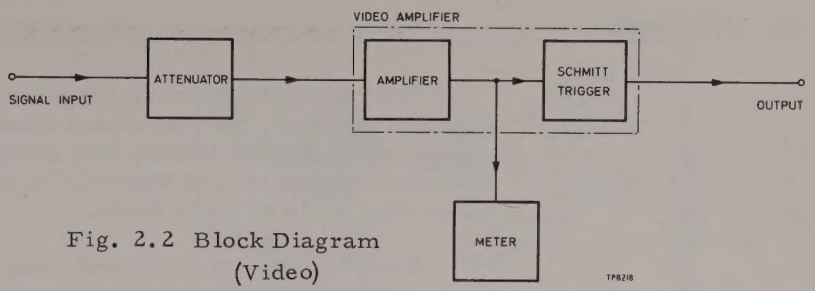


Fig. 2.2 Block Diagram (Video)

With the FUNCTION switch in this position the instrument measures signals in the range 20 kc/s to 10.5 Mc/s.

Functional Description

A block diagram of the operation of the Converter in this setting is given in Fig. 2.2.

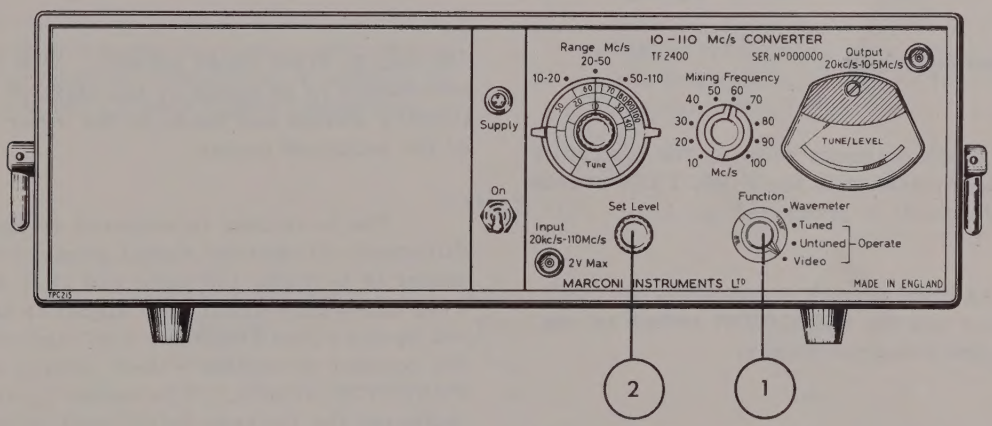
The signal is taken via a 50 Ω, 110 dB attenuator (the SET LEVEL control) and the FUNCTION switch to the video amplifier. The amplifier output drives a Schmitt trigger circuit, used so that signals below a minimum level will not operate the counter.

The Schmitt trigger produces a rectangular wave of approximately 2 V amplitude to drive the counter.

The output from the amplifier is also rectified and used to drive the meter. This indicates when there is sufficient level to reliably operate the trigger circuit and hence the counter. A green band on the meter scale indicates the correct drive level.

In this setting of the FUNCTION switch, the RANGE Mc/s switch, the MIXING FREQUENCY switch, and the TUNE dial are inoperative.

Input sensitivity : 10 mV r.m.s.



Operating Procedure

Caution : The voltage level applied to the INPUT socket must not exceed 2 V r.m.s.

(1) Set the FUNCTION switch to 'Video'.

(2) Adjust the SET LEVEL control to give a meter deflection in the green band. (If the pointer will not reach the green band the signal amplitude is too small to drive the counter.)

Read the signal frequency directly on the counter.

2.5 UNTUNED

With the FUNCTION switch set to the 'Untuned' position, the instrument measures signals which are reasonably free from spurious frequencies and which lie in the range 10.1 Mc/s to 110.5 Mc/s.

The frequency of the signal being measured should be known to within about 10 Mc/s, in order that the correct mixing harmonic can be selected. If it is not known, see Section 2.7 describing the operation of the wavemeter.

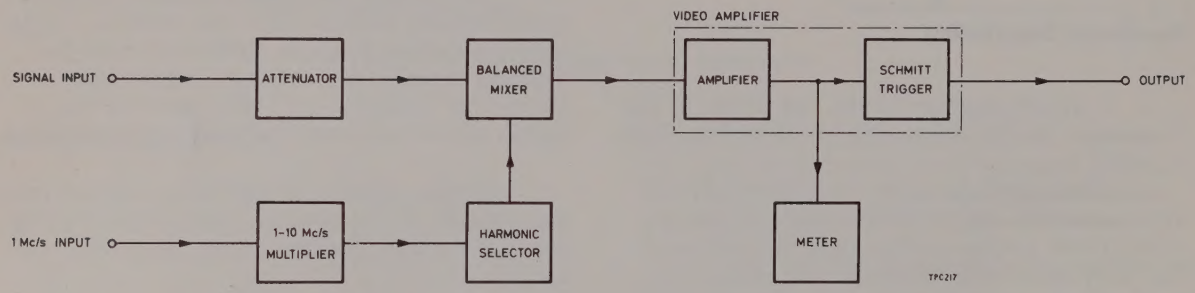


Fig. 2.3 Block Diagram (Untuned)

Functional Description

A block diagram showing the operation of the instrument with the FUNCTION switch set to 'Untuned' is given in Fig. 2.3.

The input signal is taken via the 50 Ω attenuator and the FUNCTION switch to one input of the balanced mixer.

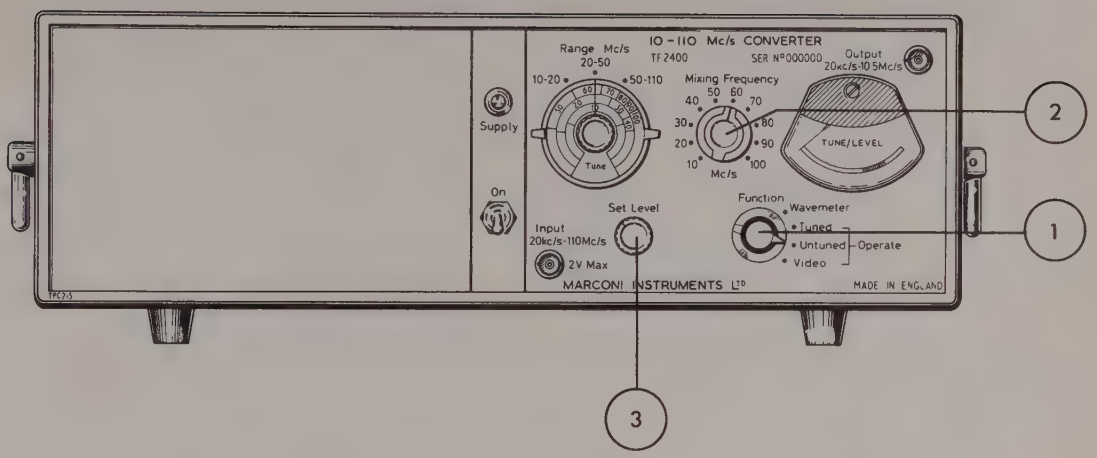
The 1 Mc/s standard frequency signal, from the counter, is fed to the 1-10 Mc/s multiplier, where sharp pulses at a repetition rate of 10 Mc/s are produced and delivered to the harmonic selector.

In the harmonic selector tuned circuits select harmonics, ranging from 10 Mc/s to 100 Mc/s, from these pulses. One of these harmonics is selected by the MIXING FREQUENCY switch and taken to the other input of the balanced mixer.

The harmonic is selected so that the difference-frequency signal produced in the mixer is between 100 kc/s and 10.5 Mc/s. This difference-frequency signal is amplified by the video amplifier and used to drive the counter as on the 'Video' setting of the FUNCTION switch. The meter again indicates the correct drive level to the counter.

In this setting of the FUNCTION switch, the RANGE Mc/s switch and the TUNE dial are inoperative.

Input sensitivity : 10 mV r.m.s.



Operating Procedure

Caution : The voltage level applied to the INPUT socket must not exceed 2 V r.m.s.

(1) Set the FUNCTION switch to 'Untuned'.

(2) Set the MIXING FREQUENCY switch to the harmonic of 10 Mc/s next below the frequency to be measured.

(3) Adjust the SET LEVEL control to give a meter deflection in the green band.

(2) Read the frequency on the counter and add this to the harmonic indicated on the MIXING FREQUENCY switch, to give the correct signal frequency.

Note : There will always be two, and sometimes three positions of the MIXING FREQUENCY switch where an output adequate to drive the counter is obtained. Examples of this are shown in Table 2.1

Where it is possible to select only two harmonics the difference frequencies will always sum to 10 Mc/s; where three harmonics are selectable the difference frequencies for two of them will sum to 10 Mc/s. In either case, the lower of these two harmonic frequencies should be used so that the counter reading is added to it. If the higher frequency is selected the counter reading will have to be subtracted from the harmonic frequency.

TABLE 2.1.

Signal Frequency (Mc/s)	Harmonic (Mc/s)	Difference Frequency (Mc/s)
54.2	*50	4.2
54.2	60	5.8
70.7	60	10.7
70.7	*70	0.7
70.7	80	9.3
89.1	*80	9.1
89.1	90	0.9
89.1	100	10.9

* Indicates the harmonic which should be used.

2.6 TUNED

With the FUNCTION switch in this position the instrument measures signals in the range 10.1 Mc/s to 110 Mc/s. The main use of this switch position is for input signals which contain unwanted frequencies. The frequency should be known to within about 10 Mc/s so that the correct harmonic can be selected. If it is not, see Section 2.7 describing the operation of the Wavemeter.

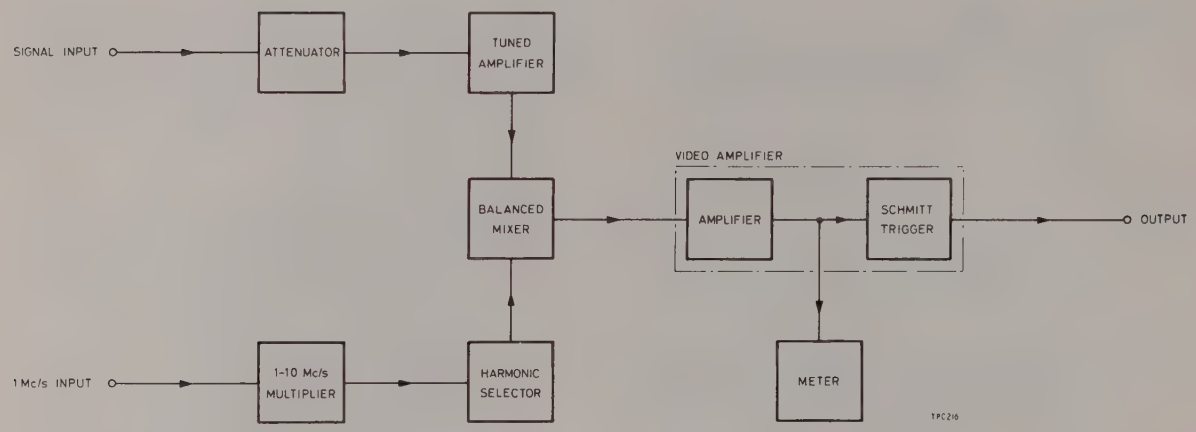


Fig. 2.4 Block Diagram (Tuned)

Functional Description

A block diagram of the operation of the Converter with the FUNCTION switch set to the 'Tuned' position, is given in Fig. 2.4.

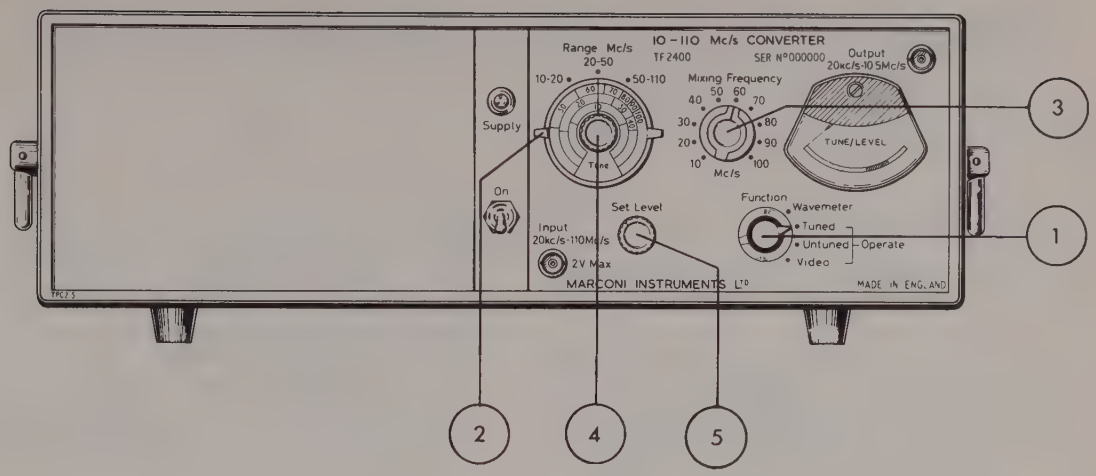
The input signal is taken via the 50 Ω attenuator and the FUNCTION switch to the tuned amplifier.

There are three amplifier tuning ranges, 10-20 Mc/s, 20-50 Mc/s and 50-110 Mc/s, and tuning is controlled by the RANGE Mc/s switch together with its associated concentric tuning dial. The switch selects one of the ranges and continuous cover over that range is effected by the TUNE dial, which is calibrated in 10 Mc/s steps.

The output from the tuned amplifier is taken to one input of the balanced mixer.

The other input to the mixer is obtained in the same way as when the instrument is operating with the FUNCTION switch in the 'Untuned' position; the standard frequency signal is fed via the multiplier to the harmonic selector, and the resulting harmonic of 10 Mc/s taken to the balanced mixer. The output from the mixer is taken to the counter as described in Section 2.4.

Input sensitivity : 10 mV r.m.s.



Operating Procedure

Caution : The voltage level applied to the INPUT socket must not exceed 2 V r.m.s.

(1) Set the FUNCTION switch to 'Tuned'.

(2) Set the RANGE Mc/s switch to band in which signal is known to lie.

(3) Set the MIXING FREQUENCY switch to the harmonic of 10 Mc/s next below the frequency to be measured.

(4) Adjust the TUNE dial for maximum meter deflection. (Note : Frequency in band under cursor should be the same as that on the MIXING FREQUENCY switch.)

(5) Adjust the SET LEVEL control for a meter deflection in the green band.

(3) Read the frequency on the counter and add this to the harmonic indicated on the MIXING FREQUENCY switch, to give the correct signal frequency.

Note : Two or three positions of the MIXING FREQUENCY switch will give an output to the counter, as described in Section 2.5. (For your convenience Table 2.1 is repeated below.)

TABLE 2.1

Signal Frequency (Mc/s)	Harmonic (Mc/s)	Difference Frequency (Mc/s)
54.2	*50	4.2
54.2	60	5.8
70.7	60	10.7
70.7	*70	0.7
70.7	80	9.3
89.1	*80	9.1
89.1	90	0.9
89.1	100	10.9

* Indicates the harmonic which should be used.

2.7 WAVEMETER

With the FUNCTION switch in this position the instrument gives an indication of the frequency of unknown inputs in the range 20 kc/s to 110.5 Mc/s.

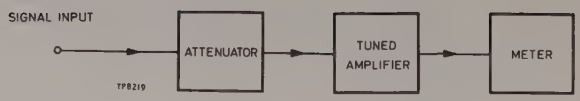


Fig. 2.5 Block Diagram (Wavemeter)

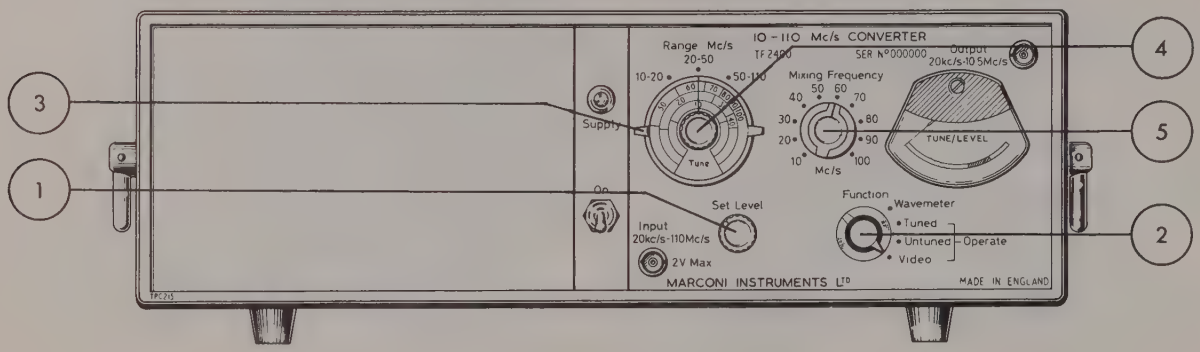
Functional Description

A block diagram of the operation of the Converter in this setting is given in Fig. 2.5.

This is not an operating position in which the frequency may be accurately measured, but is used to give an approximate indication of the frequency of a completely unknown signal so that the correct switch settings may be selected.

The signal is first tested on the 'Video' setting to determine if it lies in the range 20 kc/s to 10.5 Mc/s; if so it is passed via the video amplifier to the counter. If the signal lies in the frequency range 10-110 Mc/s it is taken via the attenuator and FUNCTION switch to the tuned amplifier. The amplifier output is not taken to the mixer, as in the 'Tuned'position, but has a dummy load to simulate the mixer loading. The signal at the output of the tuned amplifier is rectified and switched to the meter.

In this setting of the FUNCTION switch the MIXING FREQUENCY switch is inoperative.



Operating Procedure

Caution : The voltage level applied to the INPUT socket must not exceed 2 V r.m.s.

(1) Turn the SET LEVEL control fully clockwise.

(2) Set the FUNCTION switch to 'Video', and determine if output is in this range. If so, proceed as in Section 2.4. If not proceed as follows :

(2) Set the FUNCTION switch to 'Wavemeter'.

(3) Set the RANGE Mc/s switch to '10-20 Mc/s'. Adjust the TUNE dial slowly

(4) through the calibrated range appropriate to this switch setting and observe the meter for a deflection.

Repeat for '20-50 Mc/s' and '50-110 Mc/s' ranges until a meter deflection is observed.

(4) When a deflection is seen in the calibrated range, adjust the TUNE dial for maximum deflection. Adjust the SET

(1) LEVEL control, if necessary, to keep the pointer on the scale.

(5) Set the MIXING FREQUENCY switch to harmonic indicated by band under the cursor on the TUNE dial.

(2) Set the FUNCTION switch to 'Untuned' or 'Tuned', as desired, and operate the instrument accordingly.

3 DESIGN DETAILS AND MAINTENANCE

3.1 GENERAL

This section of the handbook describes how the instrument works and serves as a general guide to its servicing. In case of difficulties please write or phone our Service Division, or nearest Area Office or Agent. Always mention the type number and serial number of your instrument.

Semiconductor devices are used throughout the instrument, and although these have inherent long term reliability and mechanical ruggedness, they are susceptible to damage by overloading, reversed polarity, and excessive heat or radiation. Avoid hazards such as prolonged soldering, strong r.f. fields or other forms of radiation, short circuits, or use of insulation testers.

The performance figures shown in this section of the handbook are given as a guide to the correct setting up of the instrument. They are typical results taken on one instrument, and variations must be expected due to normal component tolerances etc.

3.2 REMOVING THE CONVERTER UNIT

Most components are made available by removing the instrument covers, but it may be found more convenient to remove the Converter unit from the body when servicing.

Remove top and bottom covers. The covers are removed by withdrawing the four screws on each side of the instrument, those above the handles freeing the top cover and those below freeing the bottom cover. From the underside of the instrument remove the miniature coaxial plug, connecting the 1 Mc/s standard via the flying lead, from the socket fixed to the inside of the rear panel of the instrument. From the top unplug the power lead from the socket on the power supply printed board. Remove the two special hexagon headed screws at the back of the unit. These connect with the nuts fixed onto the rear plate of the Converter unit, and are removed from the power supply side. The unit may now be slid out from the front of the instrument.

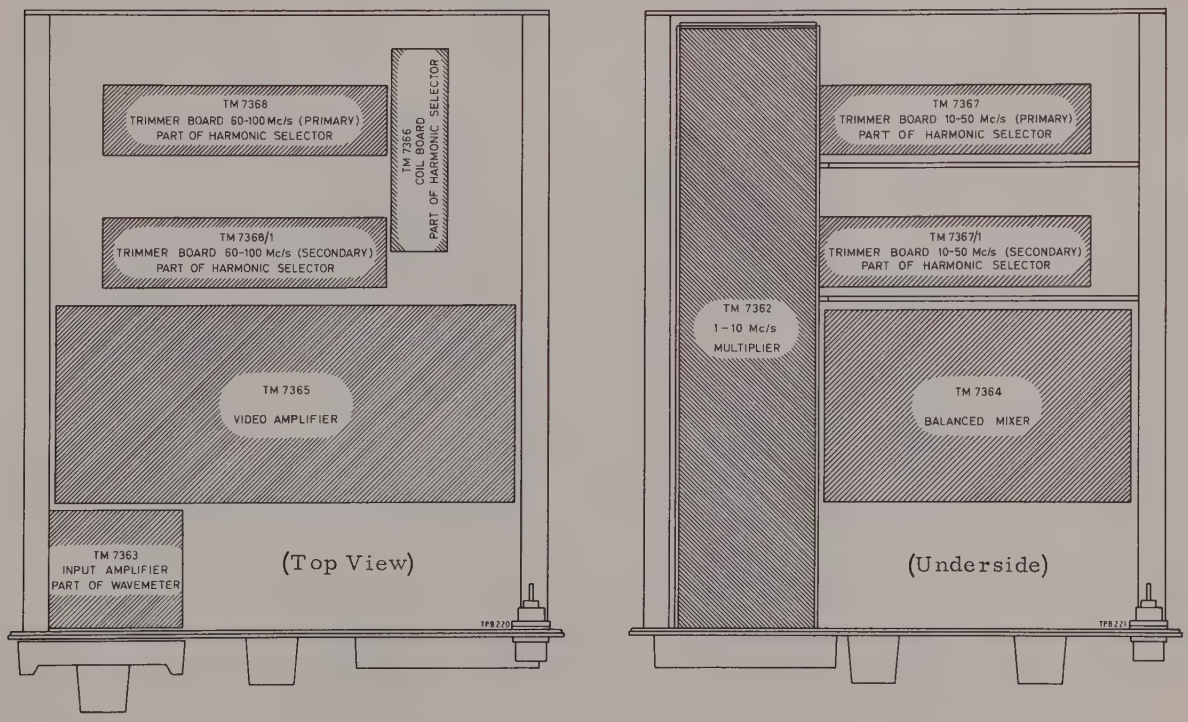


Fig. 3.1 Printed Board Distribution

3.3 POWER SUPPLY

Circuit Description

The power supply provides three stabilized lines, at +7 V, -15 V and -40 V, which are used to drive the TF 2400 and also the 100-500 Mc/s Converter TM 7164, when it is fitted. The regulation of the supply is sufficient to permit its use either with the 10-110 Mc/s Converter alone, or with both units together.

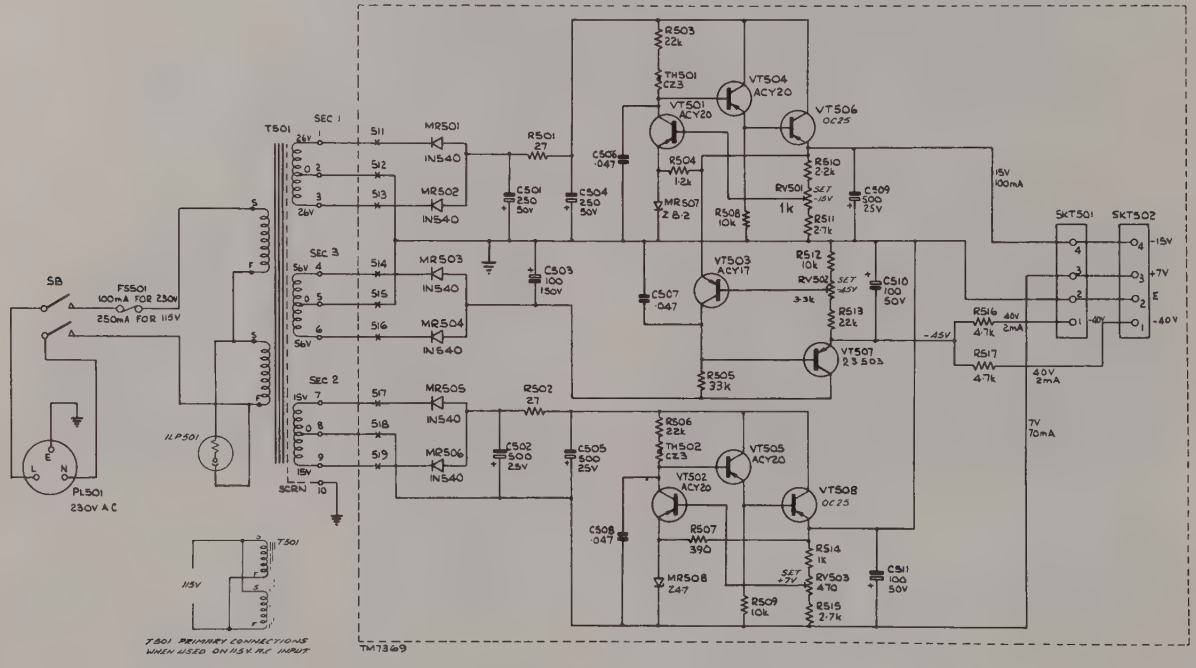
The instrument operates from either 230 V or 115 V mains supplies, the transformer tappings being adjusted for the supply voltage available. The stabilization is adequate to cover any further variations from 190 V to 260 V, and 95 V to 130 V.

All three lines are obtained from centre tapped secondaries using full wave rectification by means of silicon diodes.

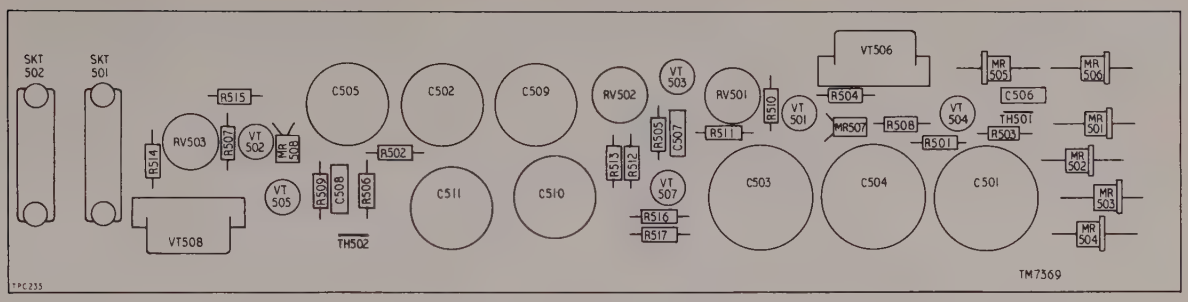
+7 V LINE. The smoothed output from the rectifier provides the d.c. output via the series stabilizing transistor VT508, the output being taken from the emitter of this transistor. VT502 has its emitter voltage stabilized by the Zener diode, MR508 fed from the emitter of VT508. A portion of the output is tapped off by RV503 and fed back to the base of VT502. Small changes in the output voltage will cause changes in current at the collector of VT502 which are amplified by emitter follower VT505, and then taken to VT508 in such a phase as to oppose the original change. VT505 also provides a low source-impedance to enable the output emitter follower, VT508, to give a low output impedance.

Thermistor, TH502, is included to give temperature compensation. As increase in temperature causes the Ico' of VT502 to increase and the potential at its collector to drop. This effect is counteracted by the decrease in collector resistance due to the change of thermistor resistance with temperature.

Pre-set potentiometer RV503 is used to set up the correct output voltage. The output is taken to the two sockets, SKT501 and SKT502 in parallel, into which the power leads of the two Converter units are plugged.



Power Supply Circuit Diagram



Power Supply Component Layout

-15 V LINE. This line operates in exactly the same way as the +7 V line, the output level being set by RV501. The outputs are again taken to the two sockets in parallel.

-40 V LINE. This line again employs a series stabilizer VT507, and output changes are amplified by VT503 and fed back to oppose the original change. The amplifier transistor, VT503, has its emitter voltage fixed by the stabilized -15 V line, and the output voltage is set up by RV502. The output is split and fed through two resistors before being taken to the output sockets. The resistors are included to prevent damage to the stabilizer if the -40 V line is accidentally shorted. The other two lines can withstand short-circuits without damage.

Maintenance

TRANSFORMER CONNECTIONS

The transformer connections need only be changed when the instrument supply voltage is changed from the 190-260 V range to the 95-130 V range, or vice versa.

Remove the bottom cover of the instrument. A diagram showing the two connections is etched onto the plate (on the underside of the instrument) which covers them.

ACCESS TO COMPONENTS

The complete power circuit, apart from the mains transformer, input socket, etc., is on a printed board. Removing the instrument top cover gives access to all components, removing the bottom cover gives access to soldered joints should it be necessary to change any components. All pre-set controls are adjustable with the board fitted, and most servicing can be carried out without removing the board.

CALIBRATION PROCEDURE

Test gear required :-

Voltmeter 20 kΩ/V; Avo, Model 8.
L.F. Oscilloscope; 10 mV/cm.
Variable Mains Transformer. Variac.

(a) Apply the following loads to the supply

Socket 501:	Pins	2-3	680 Ω	±10%	1/10W.
		2-4	680 Ω	±10%	1/2W.
		1-2	27 kΩ	±10%	1/10W.
Socket 502:	Pins	2-3	1.2 kΩ	±10%	1/10W.
		2-4	270 Ω	±10%	1W.
		1-2	27 kΩ	±10%	1/10W.

(b) Adjust -15 V line :-
Potentiometer RV501 adjusted for -15 V between pins 2 and 4 of either output socket.

(c) Adjust -40 V line :-
With -15 V line set up, adjust potentiometer RV502 for -45 V at emitter of VT507.

(d) Adjust +7 V line :-
RV503 adjusted for +7 V between pins 2 and 3 of either output socket.

PERFORMANCE FIGURES

(for Power Supply)

Currents taken by each supply line.

Supply Line	10-110 Mc/s Converter	100-500 Mc/s Converter	Total
-40 V	1.8 mA	1.8 mA	3.6 mA
-15 V	52 mA	22 mA	74 mA
+ 7 V	5.3 mA	10 mA	15.3 mA

Stabilization of Output Voltages

The figures show the effect on the supply lines of varying the mains voltage. Both units plugged into the power supply.

Supply line	Mains Voltage		
	190 V	240 V	260 V
-45 V	44.9 V	45.0 V	45.1 V
-15 V	14.9 V	15.0 V	15.0 V
+7 V	6.7 V	7.0 V	7.1 V

D.C. Levels

230 V supply; potentiometers set for nominal output voltages. All voltages with respect to chassis and negative unless marked.

C501	26.5 V	
C502	18.0 V	(across capacitor)
C503	69.0 V	
C504	29.0 V	
C505	17.4 V	(across capacitor)

Ripple

Both units plugged into power supply. The figures given are in mV, peak-to-peak.

Supply line	Mains Voltage		
	190 V	240 V	260 V
-45 V	3.0	5.0	6.0
-15 V	4.0	4.7	4.9
+ 7 V	2.0	2.0	2.0

Transistor	Emitter	Collector
VT501	7.9 V	15.3 V
VT502	+2.3 V	0.33 V
VT503	15.0 V	45.0 V
VT504	15.2 V	26.5 V
VT505	0.21 V	10.4 V
VT506	15.0 V	26.1 V
VT507	45.0 V	68.5 V
VT508	0.01 V	10.4 V

Transformer Secondary Voltages

A.C. voltages with power supply connected and on load; 230 volt mains input.

Secondary 1	49.2 V
Secondary 2	108 V
Secondary 3	29.2 V

3.4 VIDEO AMPLIFIER AND SCHMITT TRIGGER

Circuit Description

Signals in the frequency range 20 kc/s to 10.5 Mc/s, and of 10 mV r.m.s. amplitude, are accepted by the video amplifier and given sufficient amplification to drive the counter over this range.

The amplifier consists of two transistors, VT101, VT102. VT101 has negative feedback via R103 and high frequency compensation by C103. VT102 has negative feedback via R105. The d.c. levels in the circuit are set by potentiometer RV101, which provides d.c. feedback but no a.c. feedback as the emitter of VT102 is decoupled by C105.

From the amplifier the signal passes through a low pass filter (L101, C106, C107), with a cut-off frequency of 15 Mc/s and a frequency of maximum attenuation of 20 Mc/s, chosen to reject the nearest harmonic outside the passband of the amplifier.

From the filter the signal is taken via an emitter follower (VT103) to the Schmitt trigger (VT104, VT105). The trigger circuit produces rectangular waves of approximately 2 V amplitude at the output of the instrument, and these are used to drive the counter. The trigger circuit is included so that only signals above a certain minimum level will produce an output to the counter.

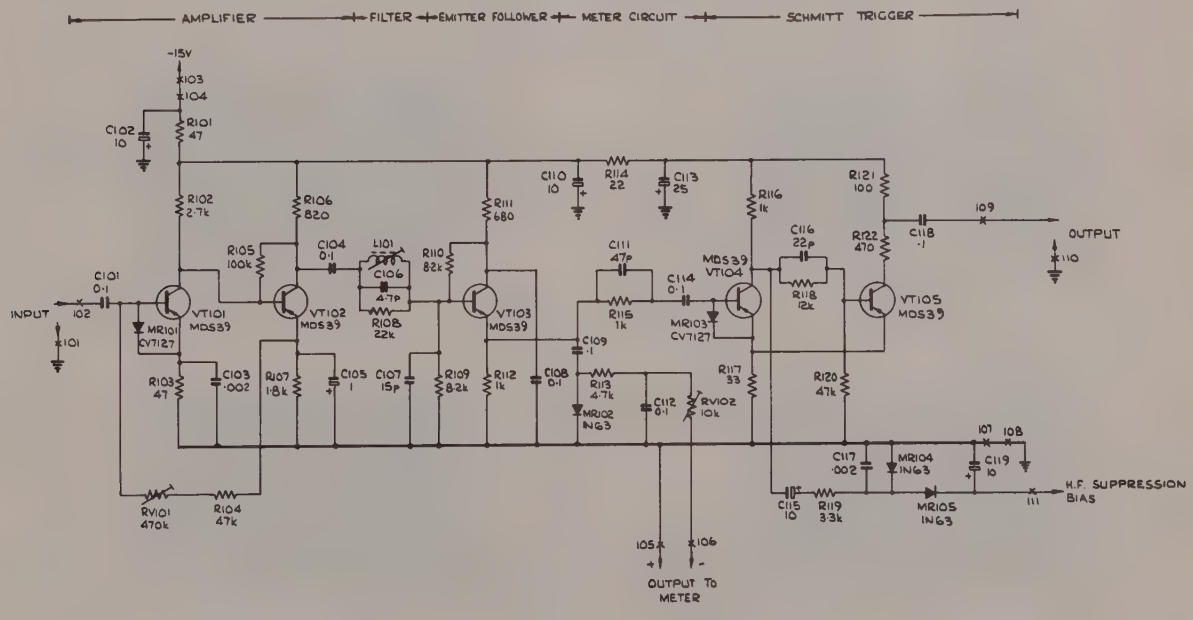
The output at the emitter of VT103 is rectified by MR102 and taken to the meter via RV102. The meter indicates the drive level to the Schmitt trigger and RV102 is adjusted so that a meter deflection in the green band indicates sufficient signal to operate the trigger and hence the counter.

Maintenance

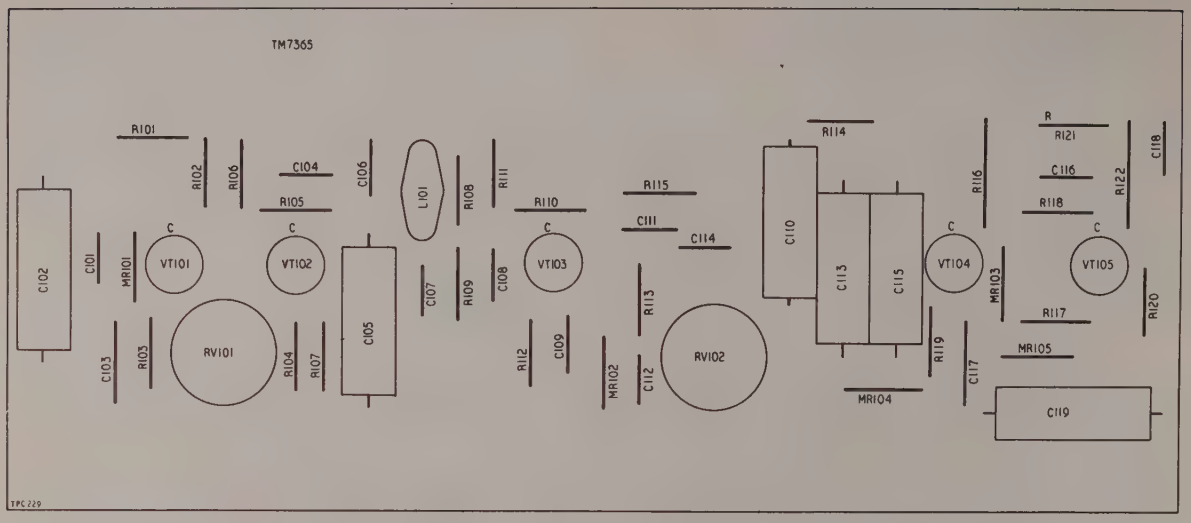
CALIBRATION PROCEDURE

Test Gear required :-

Voltmeter; 20 kΩ/V. Avo, Model 8.
Standard Signal Generator; 15 kc/s - 12 Mc/s. Marconi Type TF 144H.
Oscilloscope; 15 Mc/s (minimum) bandwidth, 100 mV/cm. Marconi type TF 2200.



Video Amplifier Circuit Diagram



Video Amplifier Component Layout

(a) Set up d.c. levels of VT101 and VT102:- Apply 100 kc/s input signal of sufficient amplitude to give limiting of peaks at the base of VT103 (approximately 20 mV will be required). Adjust RV101 for approximately equal limiting of positive and negative peaks.

(b) Set up high frequency response :- With a small input signal (approximately 5 mV) adjust coil L101 so that the signal level (measured on the oscilloscope) at the emitter of VT103 is the same at 10.5 Mc/s as at 1 Mc/s.

(c) Set up meter circuit :- Apply 1 Mc/s input signal and adjust level so that the converter just drives the counter correctly. Adjust potentiometer RV102 so that meter pointer is at about half scale. Check at 100 kc/s and 10.5 Mc/s that the counter is driven correctly with the meter just below the green band. The signal level into the instrument, to give half scale deflection, should not exceed 6 mV.

(d) Set up sensitivity :- If sensitivity on the 'Video' setting to give a meter deflection in the green band is found to be appreciably greater than 5 mV, it should be reduced as follows. Apply 20 kc/s input signal and select R607 so that an input level of approximately 5 mV gives a meter deflection at lower end of the green band. Adjust L101 so that the response at 10.5 Mc/s is the same as that at 1 Mc/s. If necessary C607 may be altered to aid this adjustment.

PERFORMANCE FIGURES

D.C. Levels

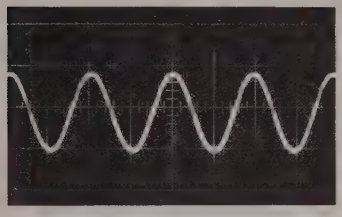
The d.c. levels of the Schmitt trigger depend on the input signal and are quoted with and without a signal present. All voltages negative with respect to earth.

	No Input	4 mV Input at 1 Mc/s
Supply	15.0 V	15.0 V
R101/R102	13.3 V	13.3 V
VT101 collector	7.4 V	7.4 V
VT102 collector	10.0 V	10.0 V
VT103 emitter	4.5 V	4.5 V
VT103 collector	10.1 V	10.1 V
R114/R116	12.8 V	12.8 V
VT104 collector	11.9 V	7.0 V
VT105 collector	0.85 V	4.4 V
R121/R122	10.6 V	11.5 V

The oscillograms were taken with a 1 Mc/s standard frequency drive, to the converter, from a TF 1417 counter.

Input : 2 mV r.m.s. at 1 Mc/s

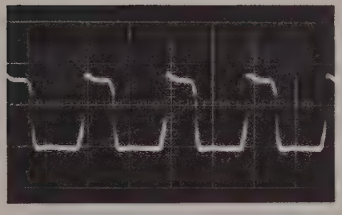
1 V/cm



VT103 emitter

TB : 0.5 µsec/cm

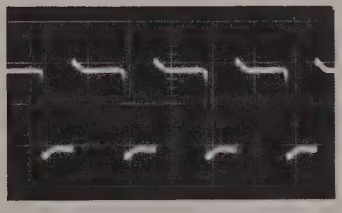
5 V/cm



VT104 collector

TB : 0.5 µsec/cm

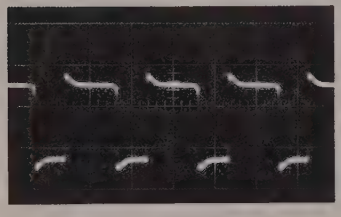
5 V/cm



VT105 collector

TB : 0.5 µsec/cm

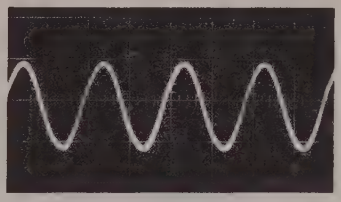
1 V/cm



Output

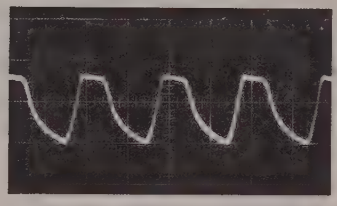
TB : 0.5 µsec/cm

Input : 1 mV r.m.s. at 10 Mc/s



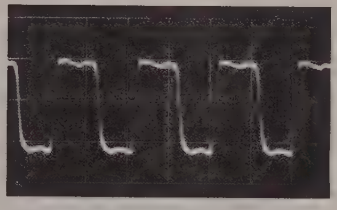
1 V/cm

TB : 0.05 µsec/cm



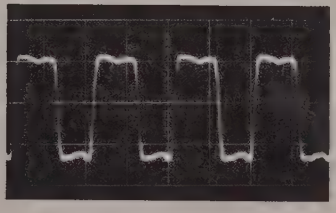
5 V/cm

TB : 0.05 µsec/cm



5 V/cm

TB : 0.05 µsec/cm



1 V/cm

TB : 0.05 µsec/cm

3.5 BALANCED MIXER

Circuit Description

In the mixer, the input signal is mixed with the harmonic of 10 Mc/s nearest below the signal frequency, giving an output in the range 100 kc/s to 10.5 Mc/s. If the input frequency is less than 100 kc/s above any harmonic, the next harmonic below is used, giving an output just over 10 Mc/s.

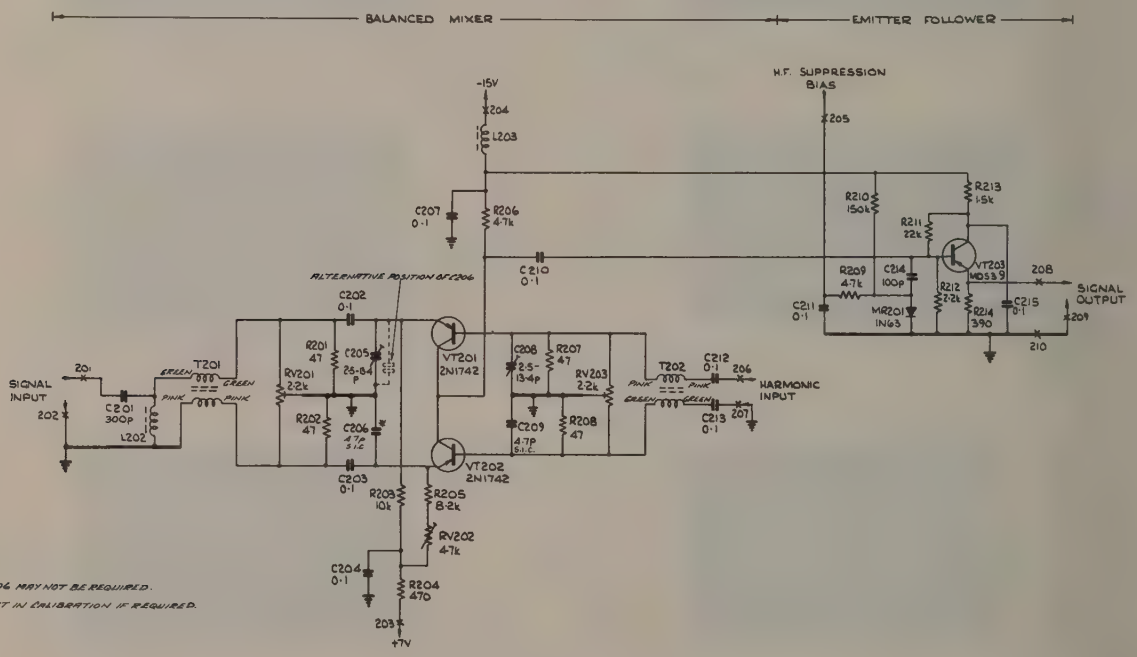
For signals in the range 10-20 Mc/s it is necessary to use a balanced mixer in which the input signals do not appear at the output because the harmonic used (10 Mc/s) is in the pass-band of the video amplifier and counter. The signal, if it is at the lower end of this range, may also lie in the pass-band. These frequencies, if allowed to appear at the output at sufficient level, could cause incorrect counter readings. With the mixer correctly balanced these input frequencies appear at the output at such small amplitudes that the counter is not affected.

It is unnecessary for the mixer to remain correctly balanced above 20 Mc/s as neither the signal nor the harmonic used is then in the pass-band of the succeeding circuits.

The input signal is taken through a high pass filter (C201, L202) having a cut off frequency of 9 Mc/s and a frequency of maximum attenuation of 5 Mc/s. The signal is then taken to the emitters of the two mixer transistors (VT201, VT202) via a transmission-line transformer (T201), used to provide a balanced, anti-phase drive to the transistors from the single sided input.

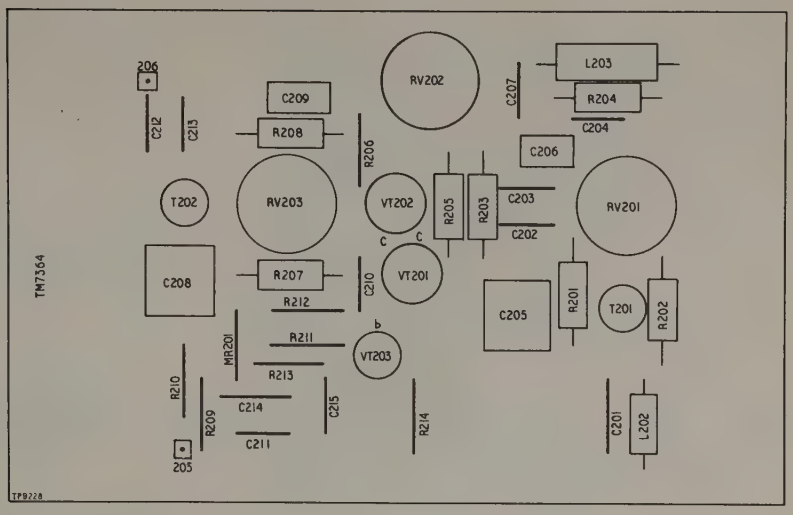
The selected harmonic of 10 Mc/s is taken via a transmission-line transformer (T202) to the bases of VT201 and VT202. The gains of these two transistors are matched to within 10%.

VT201 and VT202 are biased from the +7 V line, and one emitter circuit contains potentiometer RV202 which adjusts the bias to give equal currents in each transistor.



Balanced Mixer Circuit Diagram

Balanced Mixer
Component Layout



To ensure that the signal is correctly balanced at the two emitters, two pre-set controls are included. A resistive balance is obtained by potentiometer RV201, and a capacitive balance by C206 and trimmer C205. RV203, C208 and C209 similarly balance the harmonic input at the two bases.

The signal and the harmonic are mixed in the emitter-base circuits of the transistors, and the mixed output, consisting of the difference frequency of the signal and harmonic, appears at the common collectors. The signal frequency and the harmonic frequency are in anti-phase in the two transistors and cancel out at the collectors when the circuits are balanced.

The output is taken to emitter follower VT203 to provide a low impedance output to the video amplifier.

Maintenance

Before any attempt is made to correct faults on this circuit, it is essential that the video amplifier, 1-10 Mc/s multiplier, and the harmonic selector circuits are operating correctly.

Should it be necessary to change either transistor VT201 or VT202, it must be remembered that the gains of these transistors should be matched to within 10%.

CALIBRATION PROCEDURE

Test gear required :-

Standard Signal Generator; 15 kc/s - 12 Mc/s. Marconi Type TF 144H.
Oscilloscope; 15 Mc/s (minimum) bandwidth, 100 mV/cm. Marconi Type TF 2200.
Voltmeter; 20 kΩ/V. Avo, Model 8.

(a) Connect the 1 Mc/s standard input with multiplier and harmonic selector operating.

(b) Set the FUNCTION switch to 'Untuned', the MIXING FREQUENCY switch to '10 Mc/s', and the SET LEVEL control fully clockwise.

(c) Apply an input signal of approximately 10 mV amplitude at approximately 10.5 Mc/s. Monitor with the oscilloscope on emitter of VT103 on the video amplifier.

(d) Set potentiometers RV201, RV202, RV203, and trimmers C205, C208 to mid-travel.

(e) Remove the input signal and adjust RV202 for minimum amplitude of 10 Mc/s harmonic at VT103. Now adjust RV203 and C208 for minimum amplitude of 10 Mc/s harmonic.

(f) Remove the 1 Mc/s drive and restore the input signal. Adjust RV201 and C205 for minimum signal at VT103.

(g) Adjust emitter and base balance circuits alternately, removing the harmonic and signal inputs respectively until the best settings are obtained for minimum break-through of signal and harmonic. It will be found necessary to do this a few times as the two circuits are not completely independent. It may be necessary to alter the value of C206.

(h) Restore the signal and harmonic, and make final adjustments to the potentiometers and trimmers to give the cleanest difference frequency signal.

PERFORMANCE FIGURES

D.C. Levels

Voltages are negative with respect to earth.

VT201/VT202	Collector	8.5 V
VT203	Emitter	0.85 V
VT203	Collector	11.3 V

3.6. HIGH FREQUENCY SUPPRESSION CIRCUIT

Circuit Description

The circuit diagram of this unit is included as part of the video amplifier and balanced mixer circuit diagrams.

This circuit is included to remove spurious high frequencies (particularly 10 Mc/s) which may be present with low-frequency signals. It is not possible to filter these frequencies as high-frequency signals must also be passed.

Diode MR201 is normally biased off by R210 from the negative supply. A low frequency signal (of the order of 100 kc/s to 500 kc/s) at the collector of VT104 produces a small positive biasing voltage across MR104, which is passed via MR105 and is sufficient to overcome the negative bias on MR201, making it conduct. Any high frequency signal present with the desired low frequency signal is then heavily loaded by C214 and MR201 and is greatly reduced in amplitude. The capacitor presents a high impedance to the low frequency signal which is therefore passed unattenuated.

If the signal itself is a high frequency (above about 500 kc/s) capacitor C117 is a low impedance path preventing sufficient voltage being developed across MR104 to bias on MR201, so C214 does not affect the signal.

Maintenance

This circuit will need no maintaining other than the replacement of faulty components.

PERFORMANCE FIGURES

D.C. Levels

The voltages were measured at pin 205 with a 10 mV signal applied on the 'Video' position.

FREQUENCY	VOLTAGE
20 kc/s	+2.35 V
100 kc/s	+1.4 V
200 kc/s	+0.75 V
500 kc/s	+0.05 V
1 Mc/s	-0.17 V
5 Mc/s	-0.28 V
10 Mc/s	-0.29 V

3.7 1–10 Mc/s MULTIPLIER

Circuit Description

The multiplier takes a 1 Mc/s standard frequency input from the counter and produces pulses at 10 Mc/s repetition rate from which harmonics of 10 Mc/s, up to 100 Mc/s, can be extracted.

To reduce any unwanted frequencies which may be present, the 1 Mc/s input is first passed through a 1 Mc/s filter C302, L301, which is tunable by L301.

From the filter, the signal is taken to a two stage limiting amplifier (VT301, VT302) and via a differentiating network to transistor VT303. This is normally non-conducting, but is biased on by the negative spikes from the previous stage. The two 5 Mc/s tuned circuits associated with VT303 are loosely coupled by C309. These circuits select the fifth harmonic of the 1 Mc/s input, and a small part of this is tapped off from L303 and taken to VT304. To avoid the need for a large drive this transistor is biased on. The associated 10 Mc/s tuned circuits are again loosely coupled by C316.

The 10 Mc/s signal from this stage is taken from a tapping on L305 and is amplified by VT305, which limits the positive peaks. The negative spikes, with 10 Mc/s repetition rate, from this transistor are used to drive the avalanche transistor VT306. At the collector of VT306, large amplitude positive spikes are obtained and differentiated to give a 10 Mc/s pulse output from the multiplier.

Maintenance

ACCESS TO COMPONENTS

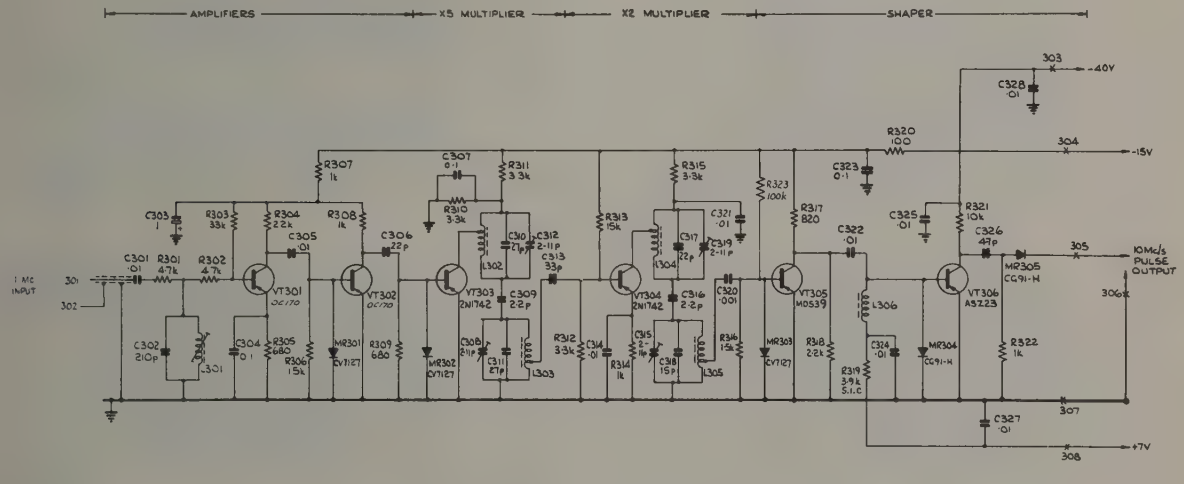
The printed circuit board is completely enclosed in a screening box. This is accessible from the bottom of the Converter and removal of the two screws in the top of the box allows the lid to be removed, giving access to the circuit board.

CALIBRATION PROCEDURE

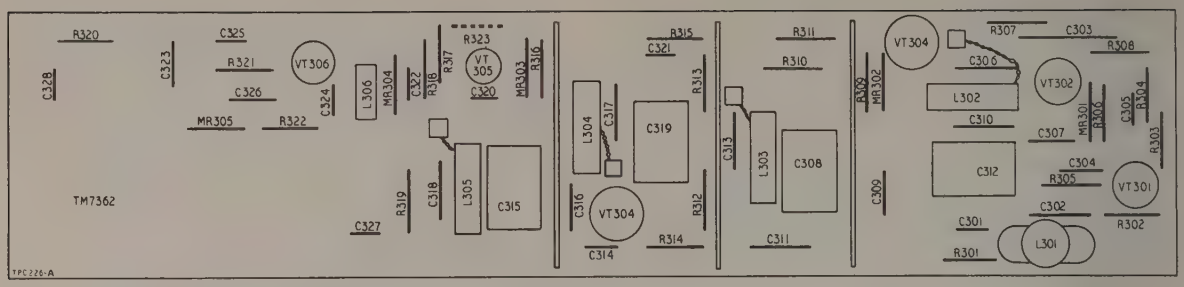
Test gear required :-

Standard Signal Generator; 15 kc/s - 12 Mc/s. Marconi Type TF 144H.
Signal Generator; 10-110 Mc/s Marconi Type TF 995A Series.
Oscilloscope; 100 Mc/s bandwidth 100 mV/cm.
Counter; Marconi Type TF 1417 series.
Voltmeter; 20 kΩ/V. Avo, Model 8.

(a) Remove screening box lid. Apply a standard 1 Mc/s input from the signal generator set to 1 Mc/s by means of the counter.



Multiplier Circuit Diagram



Multiplier Component Layout

(b) Monitor with the oscilloscope on L302 tapping. Tune L301 for a maximum, after reducing the 1 Mc/s drive level to the minimum which will give an output at this tapping. When the input circuit is tuned, set the signal generator for 250 mV input.

(c) Monitor on L303 tapping. Adjust C312 and C308 for maximum 5 Mc/s signal.

(d) Monitor on L305 tapping. Readjust C308, and adjust C319 and C315 for maximum 10 Mc/s signal.

(e) Monitor on collector of VT306. This should give 10 Mc/s spikes. Turn down the 1 Mc/s drive to the minimum necessary to produce these spikes, and re-tune L301 for best sensitivity.

(f) Replace the lid of the multiplier box, and screw down. Re-tune all trimmers for cleanest 10 Mc/s signal monitored at the output of the box. The trimmers should be adjusted to give minimum sub-harmonic present rather than for maximum 10 Mc/s. Check that the trimmers are not at the end of their travel.

The following final adjustments to the multiplier should be carried out only after the Video Amplifier, Harmonic Selector and Balanced Mixer are operating correctly. The lid of the multiplier box must be in position when the final adjustments are being made. The 1 Mc/s standard input, should be obtained from the 1 Mc/s output of the counter.

(g) Set the FUNCTION switch to 'Untuned' and the MIXING FREQUENCY switch to '100 Mc/s'. Apply an input signal of approximately 10 mV at about 105 Mc/s. Adjust SET LEVEL control for a meter deflection in the green band.

(h) Observe waveform of 5 Mc/s difference frequency at emitter of VT103. Adjust all the trimmers of the 1-10 Mc/s multiplier for the best compromise giving a large difference frequency amplitude and small 1 Mc/s and 10 Mc/s break-through.

NOTE : When observing 10 Mc/s waveforms it will be found convenient to synchronize the oscilloscope from the 1 Mc/s standard input.

PERFORMANCE FIGURES

D.C. Levels

Readings taken with and without the 1 Mc/s standard input (1.6 V peak-to-peak amplitude). All voltages negative unless marked otherwise.

	No Input	1 Mc/s Input
Supply	-15.0 V	-15.0 V
Supply	+7.6 V	+7.0 V
Supply	-39.0 V	-38.0 V
R307/R320	13.9 V	13.3 V
R307/R304	11.7 V	8.7 V
VT301 emitter	1.2 V	0.8 V
VT301 collector	7.2 V	5.8 V
VT302 collector	11.7 V	4.7 V

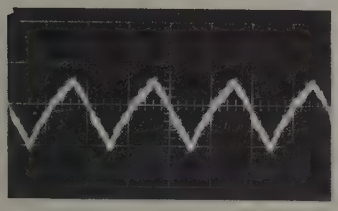
VT303 collector	7.2 V	5.8 V
VT304 collector	7.6 V	6.85 V
VT304 emitter	2.0 V	2.05 V
VT305 collector	10.5 V	7.85 V
VT306 collector	26.0 V	18.7 V

1 Mc/s Drive Level

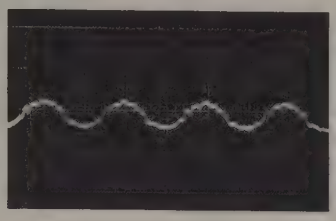
The level of 1 Mc/s required to correctly operate the multiplier was checked with drive from a TF 867 and found to be 50 mV r.m.s. The circuit operated with a drive up to at least 5 V.

OSCILLOGRAMS

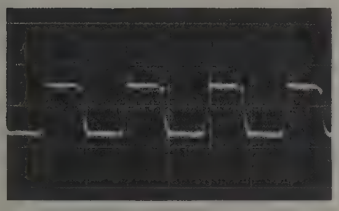
The oscillograms were taken with the lid of the screening box removed once the circuit had been tuned. A 1 Mc/s standard frequency signal from a TF 1417 counter was used to drive the converter.

0.5 V/cm  Input

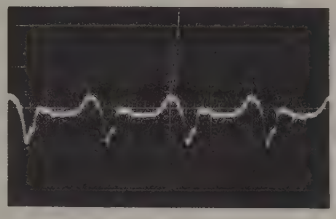
TB : 0.5 µsec/cm

L305 tap  1 V/cm

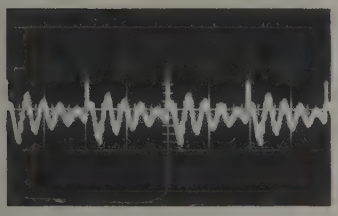
TB : 0.05 µsec/cm

5 V/cm  VT302 collector

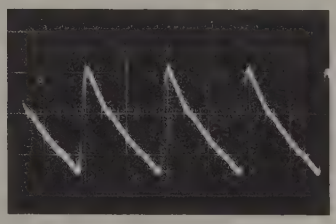
TB : 0.5 µsec/cm

VT305  1 V/cm

TB : 0.05 µsec/cm

1 V/cm  VT303 collector

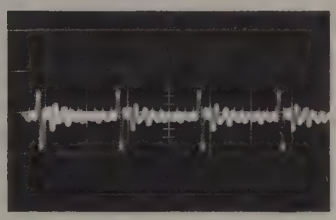
TB : 0.5 µsec/cm

VT306  5 V/cm

TB : 0.05 µsec/cm

1 V/cm L303 tap

TB : 0.1 µsec/cm

Output (tuned, with lid on)  1 V/cm

TB : 0.05 µsec/cm

3.8 HARMONIC SELECTOR

Circuit Description

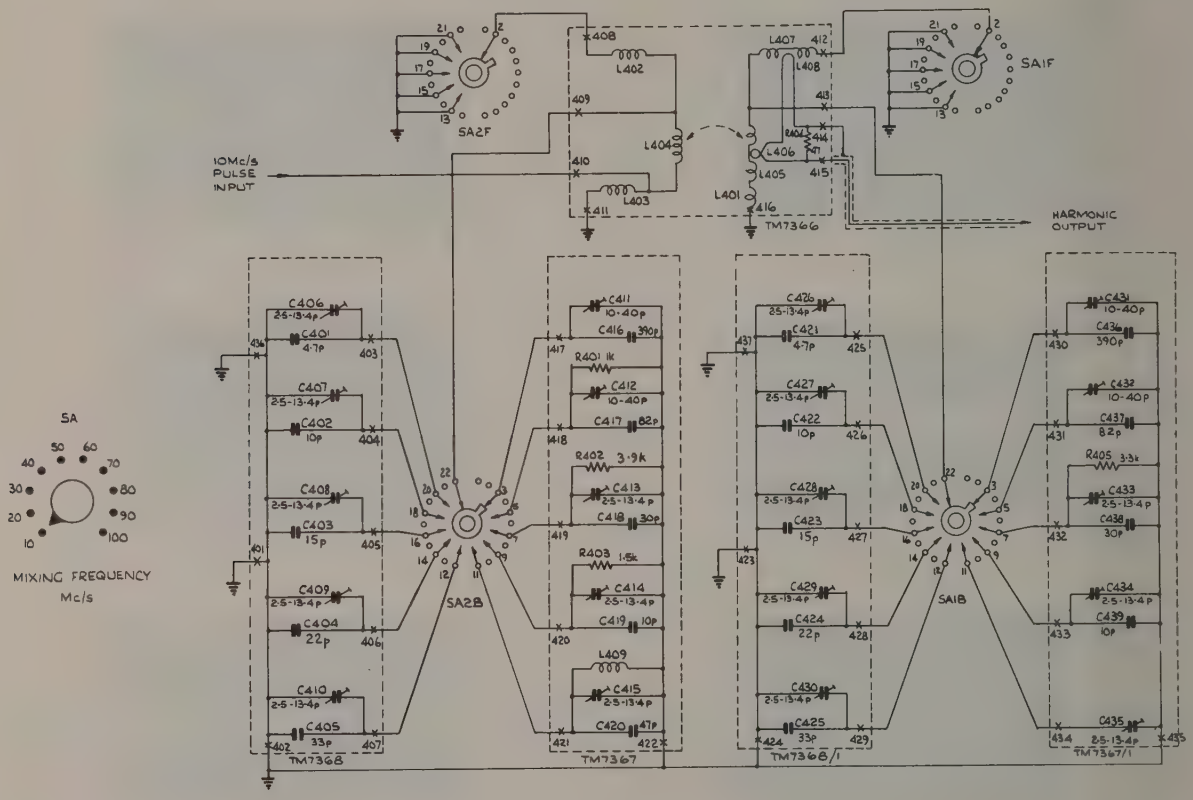
The harmonic selector consists of a pair of inductively coupled tuned circuits, each of which can be tuned to any of the harmonics of 10 Mc/s, up to 100 Mc/s.

The pulses from the multiplier, at 10 Mc/s repetition rate, are injected into the primary circuit at the junction of L403 and L404. For the ranges 10 Mc/s to 50 Mc/s these coils are tuned by trimmers C411 to C415 and their associated fixed capacitors, the frequency being selected by the MIXING FREQUENCY switch. For the ranges 60 Mc/s to 100 Mc/s a small coil (L402) is switched in parallel with the other coils, across the tuning capacitors C406 to C410.

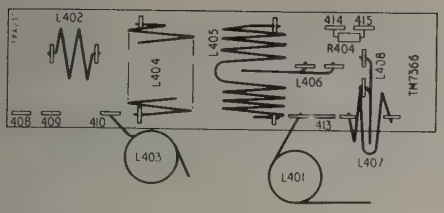
L404 is inductively coupled to the main tuning coil (L405) of the secondary. For the ranges 10 Mc/s to 50 Mc/s coils L405, L401 are tuned by C431 to C435 with their fixed capacitors. For the ranges 60 Mc/s to 100 Mc/s L407 is switched in parallel with the main coil to tune with C426 to C430.

Several of the tuning capacitors have damping resistors to give approximately equal outputs on each range. On the primary of the 50 Mc/s range, coil L409 improves the L/C ratio.

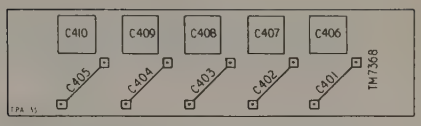
The harmonic output is taken from the secondary circuit by two pick up loops (L406, L408) connected in series. The two loops are coupled to the low-frequency and high-frequency coils respectively.



Harmonic Selector Circuit Diagram

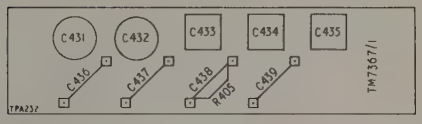


(1)

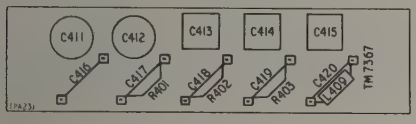


(3)

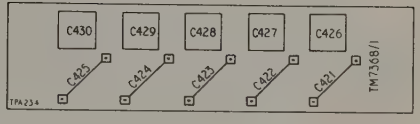
(1) Coil Board
(2) 10-50 Mc/s Trimmer Board
(3) 60-100 Mc/s Trimmer Board
(4) 10-50 Mc/s Trimmer Board
(5) 60-100 Mc/s Trimmer Board



(4)



(2)



(5)

Harmonic Selector Component Layouts

Maintenance

CALIBRATION PROCEDURE

This circuit must be set up after setting up the 1-10 Mc/s multiplier.

Test gear required :-

Standard Signal Generator; 10 Mc/s - 110 Mc/s. Marconi Type TF995A series.
Oscilloscope, 100 Mc/s bandwidth, 100 mV/cm.

(a) Set the MIXING FREQUENCY switch to 10 Mc/s and monitor the top of coil L404 (pin 409) with the oscilloscope. Set C411 to mid-travel and adjust coils L404 and L403 for maximum amplitude of 10 Mc/s sinewave.

(b) Monitor the top of coil L405 (pin 413). Set C431 to mid-travel and adjust L404, L405 and L401 for maximum 10 Mc/s signal. Tune C411 for maximum signal at this point.

(c) Monitor harmonic input to balanced mixer (pin 206). Re-adjust L405 and tune C411 and C431 for maximum signal.

NOTE : After the above procedure has been carried out, no further adjustments should be made to coils L401, L403, L404 and L405.

(d) Set the MIXING FREQUENCY switch to 20 Mc/s and monitor pin 409. Adjust C412 for maximum 20 Mc/s signal. If necessary alter C417, but allow for effect of oscilloscope capacitance.

(e) Monitor pin 413 and adjust C432 for maximum 20 Mc/s signal. Alter C437 if necessary for tuning. Re-tune C412.

(f) Monitor pin 206 and re-tune C412 and C432.

(g) Repeat stages 'd', 'e' and 'f' with the MIXING FREQUENCY switch set successively to 30 Mc/s, 40 Mc/s and 50 Mc/s, tuning the appropriate capacitors in each case.

(h) Set the MIXING FREQUENCY switch to 60 Mc/s and monitor pin 409. With C410 at mid travel adjust coil L402 for maximum 60 Mc/s signal.

(i) Monitor pin 413 and with C430 set to mid-travel adjust coils L402 and L407 for maximum 60 Mc/s. Tune C410.

(j) Monitor at pin 206. Re-adjust L407, and tune C410 and C430 for maximum 60 Mc/s signal.

NOTE : No further adjustments should be made to coils L402 and L407.

(k) For the 70 Mc/s, 80 Mc/s, 90 Mc/s and 100 Mc/s ranges repeat the procedure of stages 'd', 'e' and 'f'.

The following final adjustments to the harmonic selector should be carried out only after the Video Amplifier and the Balanced Mixer are operating correctly.

(l) Set the FUNCTION switch to 'Untuned' and the MIXING FREQUENCY switch to '10 Mc/s'. Apply input signal of approximately 10 mV amplitude at about 15 Mc/s, and adjust the SET LEVEL control for a meter deflection in the green band.

(m) Observe difference-frequency signal at the emitter of VT103 and adjust trimmers C411 and C431 for the best compromise giving large output amplitude and small harmonic break-through.

(n) Repeat this procedure for all ranges of the MIXING FREQUENCY switch in turn, using an input signal giving approximately 5 Mc/s output in each case, and adjusting the appropriate capacitors.

3.9 WAVEMETER

Circuit Description

The wavemeter gives an approximate indication of the frequency of unknown signals between 10 Mc/s and 110 Mc/s. It is also used as a tuned amplifier for the signal input on the 'Tuned' operating position.

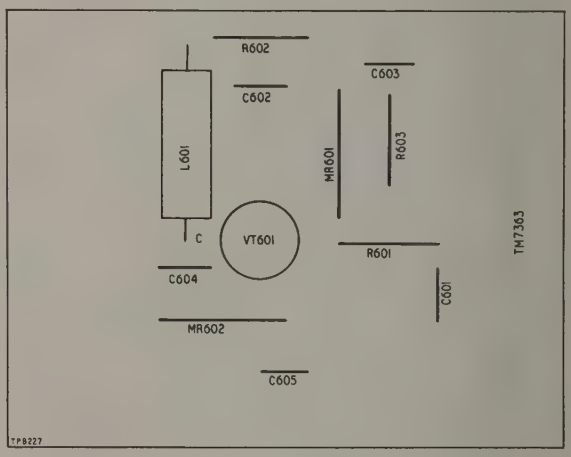
The input signal is taken to the emitter of the common base amplifier VT601. The collector circuit is tuned by the parallel circuit comprising the tuning capacitor C606 (controlled by the front panel TUNE dial) and one of the three coils L602, L603, L604. These coils are selected by the RANGE Mc/s switch and, in conjunction with the tuning capacitor, they cover each of the three tuning bands (see Interconnecting Diagram).

On the 'Tuned' setting a tapping on the appropriate range coil takes the amplified signal to the input of the balanced mixer.

On the 'Wavemeter' setting the tappings on the range coils are not taken to the mixer input, but are loaded to simulate the mixer loading. This ensures that the tuning is not affected when switching from 'Wavemeter' to 'Tuned'.

In the 'Wavemeter' position the signal at the tuned circuit is rectified by MR602 and taken to the meter. Adjusting the TUNE dial for maximum meter deflection tunes the wavemeter.

With the FUNCTION switch in the 'Video' and 'Untuned' positions the wavemeter is not connected in circuit, and its negative supply is removed to avoid the possibility of any unwanted oscillation.



Input Amplifier Component Layout

RE-ADJUSTING THE SCALE

The instrument must be operating correctly before any attempt is made to readjust the wavemeter.

Test Gear required :-

Signal Generator; 10-110 Mc/s.
Marconi Type TF 995A series.
Counter. Marconi Type TF 1417 series.
Voltmeter; 20 kΩ/V. Avo, Model 8.

If, for any reason, the wavemeter scale has been removed or moved from its original setting, it may be re-set as follows:

(a) Set the FUNCTION switch to 'Untuned', and the MIXING FREQUENCY switch to '70'.

(b) Connect an 80 Mc/s signal from the signal generator to the Converter input socket; connect the Converter output socket to the counter input socket.

(c) Adjust the signal generator frequency so that the counter readout shows exactly 10 Mc/s. The signal into the Converter is now exactly 80 Mc/s.

(d) Set the FUNCTION switch to 'Wavemeter'.

(e) Adjust the TUNE dial for maximum deflection on the meter.

(f) If necessary, remove the dial and replace with the cursor line over the 80 Mc/s mark (i.e., a mark which lies before '80'.)

(g) Re-adjust the TUNE dial for maximum meter deflection and check that the cursor line lies exactly over the 80 Mc/s mark.

NOTES :

1) Any harmonic may be used to reset the dial, but it is preferable that one at the upper end of the range is used.

2) Should the wavemeter develop inaccuracies which cannot be eradicated by the above method, the instrument should be returned to Marconi Instruments in order that the fault be cleared and the dial re-calibrated.

PERFORMANCE FIGURES

D.C. Levels

VT601 collector 9.6 V

LIST OF REPLACEABLE PARTS

Introduction

This section lists replaceable parts in alphabetical order of their circuit references. A separate parts list is given for each circuit diagram. The following abbreviations are used:

Carb	:	carbon
Cer	:	ceramic
DPDT	:	double pole, double throw
Elec	:	electrolytic
Met ox	:	metal oxide film
Plas	:	plastic
Pos	:	position
Sec	:	section
TE	:	total excursion
*	:	selected during test nominal value shown

Note: Throughout the lists, resistor wattages are referred to 70°C unless otherwise stated.

Ordering

When ordering replacement parts, address the order to our Service Department. Specify the following information for each part required.

1) Type and serial number of instrument
2) Circuit reference
3) Description
4) M.I. code number

If a part is not listed, state its function, location and description when ordering.

VIDEO AMPLIFIER: TM 7365

Circuit reference	*Description*	*M.I. code*
CAPACITORS		
C101	Cer 0.1µF +50% -25% 25V	26383-031
C102	Elec 10µF +100% -20% 35V	MIP 41767
C103	Plas 0.002µF ±2% 125V	26516-556
C104	Cer 0.1µF +50% -25% 25V	26383-031
C105	Elec 1µF +100% -20% 300V	MIP 41759
C106	Cer 4.7pF ±0.5pF 750V	26324-055
C107	Cer 15pF ±5% 750V	26324-795
C108	Cer 0.1µF +50% -25% 25V	26383-031
C109	Cer 0.1µF +50% -25% 25V	26383-031
C110	Elec 10µF +100% -20% 35V	MIP 41767
C111	Cer 47pF ±2% 750V	26324-833
C112	Cer 0.1µF +50% -25% 25V	26383-031
C113	Elec 25µF +100% -20% 18V	MIP 41719
C114	Cer 0.1µF +50% -25% 25V	26383-031
C115	Elec 10µF +100% -20% 35V	MIP 41767
C116	Cer 22pF ±5% 750V	26324-807
C117	Plas 0.002µF ±2% 125V	26516-556
C118	Cer 0.1µF +50% -25% 25V	26383-031
C119	Elec 10µF +100% -20% 35V	MIP 41767
DIODES		
MR101	CV 7127	28322-157
MR102	1N 63	28323-076
MR103	CV 7127	28322-157
MR104	1N 63	28323-076
MR105	1N 63	28323-076
L101	Inductor	TB 40505
RESISTORS		
R101	Carb 47Ω ±10% 0.1W	24341-237
R102	Carb 2.7kΩ ±10% 0.1W	24341-292
R103	Carb 47Ω ±10% 0.1W	24341-237
R104	Carb 47kΩ ±10% 0.1W	24341-326
R105	Carb 100kΩ ±10% 0.1W	24341-335
R106	Carb 820Ω ±10% 0.1W	24341-278
R107	Carb 1.8kΩ ±10% 0.1W	24341-286
R108	Carb 22kΩ ±10% 0.1W	24341-318
R109	Carb 8.2kΩ ±10% 0.1W	24341-308
R110	Carb 8.2kΩ ±10% 0.1W	24341-308
R111	Carb 680Ω ±10% 0.1W	24341-276
R112	Carb 1kΩ ±10% 0.1W	24341-280
R113	Carb 4.7kΩ ±10% 0.1W	24341-300
R114	Carb 22Ω ±10% 0.1W	24341-228
R115	Carb 1kΩ ±10% 0.1W	24341-280

Circuit reference	Description	M.I. code
R116	Carb 1kΩ ±10% ½W/55°C	24342-080
R117	Carb 33Ω ±10% 0.1W	24341-233
R118	Carb 12kΩ ±10% 0.1W	24341-312
R119	Carb 3.3kΩ ±10% 0.1W	24341-294
R120	Carb 47kΩ ±10% 0.1W	24341-326
R121	Carb 100Ω ±10% 0.1W	24341-250
R122	Carb 470Ω ±10% ½W/55°C	24342-069
VARIABLE RESISTORS		
RV101	Carb 470kΩ ±20% ¼W/70°C	25611-231
RV102	Carb 10kΩ ±20% ¼W/70°C	25611-213
TRANSISTORS		
VT101	MDS 39	28421-428
VT102	MDS 39	28421-428
VT103	MDS 39	28421-428
VT104	MDS 39	28421-428
VT105	MDS 39	28421-428
BALANCED MIXER: TM 7364		
CAPACITORS		
C201	Plas 300pF ±2% 125V	26516-358
C202	Cer 0.1μF +50% -25% 25V	26383-031
C203	Cer 0.1μF +50% -25% 25V	26383-031
C204	Cer 0.1μF +50% -25% 25V	26383-031
C205	Air 2.5 - 13.4pF	26817-238
C206	Cer 4.7pF ±0.5pF 750V *	26324-055
C207	Cer 0.1μF +50% -25% 25V	26383-031
C208	Air 2.5 - 13.4pF	26817-238
C209	Cer 4.7pF ±0.5pF 750V *	26324-055
C210	Cer 0.1μF +50% -25% 25V	26383-031
C211	Cer 0.1μF +50% -25% 25V	26383-031
C212	Cer 0.1μF +50% -25% 25V	26383-031
C213	Cer 0.1μF +50% -25% 25V	26383-031
C214	Plas 100pF ±2% 125V	26516-241
C215	Cer 0.1μF +50% -25% 25V	26383-031
MR201	Diode 1N 63	28323-076
L202	Inductor	TB23173/138
L203	Inductor	TB23173/147
RESISTORS		
R201	Met ox 47Ω ±7% TE ⅜W/55°C	24552-037
R202	Met ox 47Ω ±7% TE ⅜W/55°C	24552-037
R203	Met ox 10kΩ ±7% TE ⅜W/55°C	24552-110
R204	Met ox 470Ω ±7% TE ⅜W/55°C	24552-069
R205	Met ox 8.2kΩ ±7% TE ⅜W/55°C	24552-108
R206	Carb 4.7kΩ ±10% 0.1W	24341-300
R207	Met ox 47Ω ±7% TE ⅜W/55°C	24552-037
R208	Met ox 47Ω ±7% TE ⅜W/55°C	24552-037
R209	Carb 4.7kΩ ±10% 0.1W	24341-300
R210	Carb 150kΩ ±10% 0.1W	24341-339
R211	Carb 22kΩ ±10% 0.1W	24341-318
R212	Carb 2.2kΩ ±10% 0.1W	24341-288
R213	Carb 1.5kΩ ±10% 0.1W	24341-284
R214	Carb 390Ω ±10% 0.1W	24341-265
VARIABLE RESISTORS		
RV201	Carb 2.2kΩ ±20% ¼W/70°C	25611-206
RV202	Carb 4.7kΩ ±20% ¼W/70°C	25611-209
RV203	Carb 2.2kΩ ±20% ¼W/70°C	25611-206
TRANSFORMERS		
T201		TB40216/2
T202		TB40216/2
TRANSISTORS		
VT201	2N1742	28422-768
VT202	2N1742	28422-768
VT203	MDS 39	28421-428

See introduction to this section for symbols and abbreviations

1 - 10 Mc/s MULTIPLIER: TM 7362

Circuit reference	Description	M.I. code
CAPACITORS		
C301	Cer 0.01μF +80% -20% 100V	26383-055
C302	Cer 210pF ±2% 125V	26516-324
C303	Elec 1μF +40% -20% 15V	26483-214
C304	Cer 0.1μF +50% -25% 25V	26383-031
C305	Cer 0.01μF +80% -20% 100V	26383-055
C306	Plas 22pF ±2pF 125V	26516-088
C307	Cer 0.1μF +50% -25% 25V	26383-031
C308	Air 2 - 11pF	26812-207
C309	Cer 2.2pF ±0.5pF 750V	26324-042
C310	Plas 27pF ±2pF 125V *	26516-108
C311	Plas 27pF ±2pF 125V *	26516-108
C312	Air 2 - 11pF	26812-207
C313	Plas 33pF ±2pF 125V	26516-127
C314	Cer 0.01μF +80% -20% 100V	26383-055
C315	Air 2 - 11pF	26812-207
C316	Cer 2.2pF ±2pF 750V	26324-042
C317	Plas 22pF ±2pF 125V *	26516-088
C318	Plas 15pF ±1½pF 125V *	26516-018
C319	Air 2 - 11pF	26812-207
C320	Cer 0.001μF +80% -20% 500V	26383-242
C321	Cer 0.01μF +80% -20% 100V	26383-055
C322	Cer 0.01μF +80% -20% 100V	26383-055
C323	Cer 0.1μF +50% -25% 25V	26383-031
C324	Cer 0.01μF +80% -20% 100V	26383-055
C325	Cer 0.01μF +80% -20% 100V	26383-055
C326	Cer 4.7pF ±0.5pF 750V	26324-055
C327	Cer 0.01μF +80% -20% 100V	26383-055
C328	Cer 0.01μF +80% -20% 100V	26383-055
DIODES		
MR301	CV 7127	28322-157
MR302	CV 7127	28322-157
MR303	CV 7127	28322-157
MR304	CG 91H	28321-311
MR305	CG 91H	28321-311
INDUCTORS		
L301		TB40505/1
L302		TB23173/133
L303		TB23173/133
L304		TB23173/144
L305		TB23173/144
L306		TB23173/136
RESISTORS		
R301	Carb 4.7kΩ ±10% 0.1W	24341-300
R302	Carb 4.7kΩ ±10% 0.1W	24341-300
R303	Carb 33kΩ ±10% 0.1W	24341-322
R304	Carb 2.2kΩ ±10% 0.1W	24341-288
R305	Carb 680Ω ±10% 0.1W	24341-276
R306	Carb 1.5kΩ ±10% 0.1W	24341-284
R307	Carb 1kΩ ±10% 0.1W	24341-280
R308	Carb 1kΩ ±10% 0.1W	24341-280
R309	Carb 680Ω ±10% 0.1W	24341-276
R310	Carb 3.3kΩ ±10% 0.1W	24341-294
R311	Carb 3.3kΩ ±10% 0.1W	24341-294
R312	Carb 3.3kΩ ±10% 0.1W	24341-294
R313	Carb 15kΩ ±10% 0.1W	24341-314
R314	Carb 1kΩ ±10% 0.1W	24341-280
R315	Carb 3.3kΩ ±10% 0.1W	24341-294
R316	Carb 1.5kΩ ±10% 0.1W	24341-284
R317	Carb 820Ω ±10% 0.1W	24341-278
R318	Carb 2.2kΩ ±10% 0.1W	24341-288
R319	Carb 3.9kΩ ±10% 0.1W	24341-296
R320	Carb 100Ω ±10% 0.1W	24341-250
R321	Carb 10kΩ ±10% 0.1W	24341-310
R322	Carb 1kΩ ±10% 0.1W	24341-280
R323	Carb 100kΩ ±10% 0.1W	24341-335

See introduction to this section for symbols and abbreviations

Circuit reference	Description	M.I. code
TRANSISTORS		
VT301	OC170	28422-697
VT302	OC170	28422-697
VT303	2N 1742	28422-768
VT304	2N 1742	28422-768
VT305	MDS 39	28421-428
VT306	ASZ 23	28422-758
HARMONIC SELECTOR: TM 7366, TM 7367, TM 7367/1, TM 7368, TM 7368/1		
CAPACITORS		
C401	Cer 4.7pF ±0.5pF 750V *	26324-055
C402	Plas 10pF ±1pF 125V *	26516-009
C403	Plas 15pF ±1½pF 125V *	26516-018
C404	Plas 22pF ±2pF 125V *	26516-088
C405	Plas 33pF ±2pF 125V *	26516-127
C406	Air 2.5 - 13.4pF	26817-238
C407	Air 2.5 - 13.4pF	26817-238
C408	Air 2.5 - 13.4pF	26817-238
C409	Air 2.5 - 13.4pF	26817-238
C410	Air 2.5 - 13.4pF	26817-238
C411	Cer 10 - 40pF	26847-265
C412	Cer 10 - 40pF	26847-265
C413	Air 2.5 - 13.4pF	26817-238
C414	Air 2.5 - 13.4pF	26817-238
C415	Air 2.5 - 13.4pF	26817-238
C416	Plas 390pF ±2% 125V *	26516-387
C417	Plas 82pF ±2pF 125V *	26516-222
C418	Plas 30pF ±2pF 125V *	26516-117
C419	Plas 10pF ±1pF 125V *	26516-009
C420	Plas 47pF ±2pF 125V *	26516-165
C421	Cer 4.7pF ±0.5pF 750V *	26324-055
C422	Plas 10pF ±1pF 125V *	26516-009
C423	Plas 15pF ±1½pF 125V *	26516-018
C424	Plas 22pF ±2pF 125V *	26516-088
C425	Plas 33pF ±2pF 125V *	26516-127
C426	Air 2.5 - 13.4pF	26817-238
C427	Air 2.5 - 13.4pF	26817-238
C428	Air 2.5 - 13.4pF	26817-238
C429	Air 2.5 - 13.4pF	26817-238
C430	Air 2.5 - 13.4pF	26817-238
C431	Cer 10 - 40pF	26847-265
C432	Cer 10 - 40pF	26847-265
C433	Air 2.5 - 13.4pF	26817-238
C434	Air 2.5 - 13.4pF	26817-238
C435	Air 2.5 - 13.4pF	26817-238
C436	Plas 390pF ±2% 125V *	26516-387
C437	Plas 82pF ±2pF 125V *	26516-222
C438	Plas 30pF ±2pF 125V *	26516-117
C439	Plas 10pF ±1pF 125V *	26516-009
INDUCTORS		
L401		TB 40479
L402		TB 40480
L403		TB 40481
L404		TB 40482
L405		TB 40483
L406		TB 40484
L407		TB 40485
L408		TB 40486
L409		TB23173/142
RESISTORS		
R401	Carb 1kΩ ±10% 0.1W *	24341-280
R402	Carb 3.9kΩ ±10% 0.1W *	24341-296
R403	Carb 1.5kΩ ±10% 0.1W *	24341-284
R404	Carb 47Ω ±10% 0.1W *	24341-237
R405	Carb 3.3kΩ ±10% 0.1W *	24341-294

See introduction to this section for symbols and abbreviations

POWER SUPPLY: TM 7369

Circuit reference	Description	M.I. code
CAPACITORS		
C501	Elec 250µF +50% -20% 100V	26427-314
C502	Elec 500µF +100% -20% 25V	26427-319
C503	Elec 100µF +50% -20% 250V	26427-754
C504	Elec 250µF +50% -20% 100V	26427-314
C505	Elec 500µF +100% -20% 25V	26427-319
C506	Plas 0.047µF ±10% 200V	26582-206
C507	Plas 0.047µF ±10% 200V	26582-206
C508	Plas 0.047µF ±10% 200V	26582-206
C509	Elec 500µF +100% -20% 25V	26427-319
C510	Elec 100µF +50% -20% 50V	26427-305
C511	Elec 100µF +50% -20% 50V	26427-305
DIODES		
MR501	1N540	28357-044
MR502	1N540	28357-044
MR503	1N540	28357-044
MR504	1N540	28357-044
MR505	1N540	28357-044
MR506	1N540	28357-044
MR507	Z8.2	28371-676
MR508	Z4.7	28371-376
FS501	100mA for 230V	23411-002
	250mA for 110V	23411-004
ILP501	110V neon indicating lamp	23733-112
PL501	3 pin plug	43122-017
RESISTORS		
R501	Met ox 27Ω ±7% TE ⅜W/55°C	24552-031
R502	Met ox 27Ω ±7% TE ⅜W/55°C	24552-031
R503	Met ox 22kΩ ±7% TE ⅜W/55°C	24552-118
R504	Met ox 1.2kΩ ±7% TE ⅜W/55°C	24552-082
R505	Met ox 33kΩ ±7% TE ⅜W/55°C	24552-122
R506	Met ox 22kΩ ±7% TE ⅜W/55°C	24552-118
R507	Met ox 390Ω ±7% TE ⅜W/55°C	24552-065
R508	Met ox 10kΩ ±7% TE ⅜W/55°C	24552-110
R509	Met ox 10kΩ ±7% TE ⅜W/55°C	24552-110
R510	Met ox 2.2kΩ ±7% TE ⅜W/55°C	24552-088
R511	Met ox 2.7kΩ ±7% TE ⅜W/55°C	24552-092
R512	Met ox 10kΩ ±7% TE ⅜W/55°C	24552-110
R513	Met ox 22kΩ ±7% TE ⅜W/55°C	24552-118
R514	Met ox 1kΩ ±7% TE ⅜W/55°C	24552-080
R515	Met ox 2.7kΩ ±7% TE ⅜W/55°C	24552-092
R516	Met ox 4.7kΩ ±7% TE ⅜W/55°C	24552-100
R517	Met ox 4.7kΩ ±7% TE ⅜W/55°C	24552-100
VARIABLE RESISTORS		
RV501	Carb 1kΩ ±20% ¼W/70°C	25611-204
RV502	Carb 3.3kΩ ±20% ¼W/70°C	25611-207
RV503	Carb 470Ω ±20% ¼W/70°C	25611-246
SOCKETS		
SKT501	4 pole	54 TM7369
SKT502	4 pole	54 TM7369
T501	Transformer	43466-014
THERMISTORS		
TH501	CZ3	25683-644
TH502	CZ3	25683-644
TRANSISTORS		
VT501	ACY 20	28424-747
VT502	ACY 20	28424-747
VT503	ACY 17	28426-497
VT504	ACY 20	28424-747
VT505	ACY 20	28424-747
VT506	OC 25	28424-807
VT507	2S 305	28438-318
VT508	OC 25	28424-807

See introduction to this section for symbols and abbreviations

WAVEMETER: TM 7363

Circuit reference	Description	M.I. code
CAPACITORS		
C601	Cer 0.01μF +80% -20% 100V	26383-055
C602	Cer 0.01μF +80% -20% 100V	26383-055
C603	Cer 0.01μF +80% -20% 100V	26383-055
C604	Cer 0.01μF +80% -20% 100V	26383-055
C605	Cer 0.01μF +80% -20% 100V	26383-055
C606	Air 100pF Var	26832-747
C607	Cer 47pF ±2% 750V *	26324-833
INDUCTORS		
L601		TB23173/147
L602		35126-116
L603		44234-005
L604		44228-011
DIODES		
MR601	CV 7127	28322-157
MR602	CG 91H	28321-311
PLUGS		
PL601	Coaxial	23435-212
PL602	Coaxial	MIP 44602
PL603	Coaxial	MIP 44602
RESISTORS		
R601	Carb 33Ω ±10% 0.1W	24341-233
R602	Carb 2.2kΩ ±10% 0.1W	24341-288
R603	Carb 3.3kΩ ±10% 0.1W	24341-294
R604	Carb 100Ω ±10% 0.1W	24341-250
R605	Carb 1kΩ ±10% 0.1W	24341-280
R606	Carb 47Ω ±10% 0.1W	24341-237
R607	Carb 10kΩ ±10% 0.1W	24341-310

Circuit reference	Description	M.I. code
SOCKETS		
SKT601	Coaxial	23443-433
SKT602	Coaxial	23443-433
SKT603	Coaxial	23441-044
SKT604	Coaxial	23441-044
SKT605	Coaxial	23441-044
SKT606	Coaxial	23443-433
TRANSISTOR		
VT601	2N 1742	28422-768
MISCELLANEOUS		
ATTENUATOR		
AT601	50Ω 110dB 0.1W	44426-007
KNOBS		
	MIXING FREQUENCY	41145-208
	FUNCTION	41145-208
	SET LEVEL	41145-209
	RANGE	41142-005
METER		
M601	100μA 1000Ω	44572-206
SWITCHES		
SA	2 sec 4 pole 10 pos	44326-017
SB	DPDT	23462-157
SC	1 sec 2 pole 3 pos	44322-124
SD	3 sec 6 pole 4 pos	44323-502

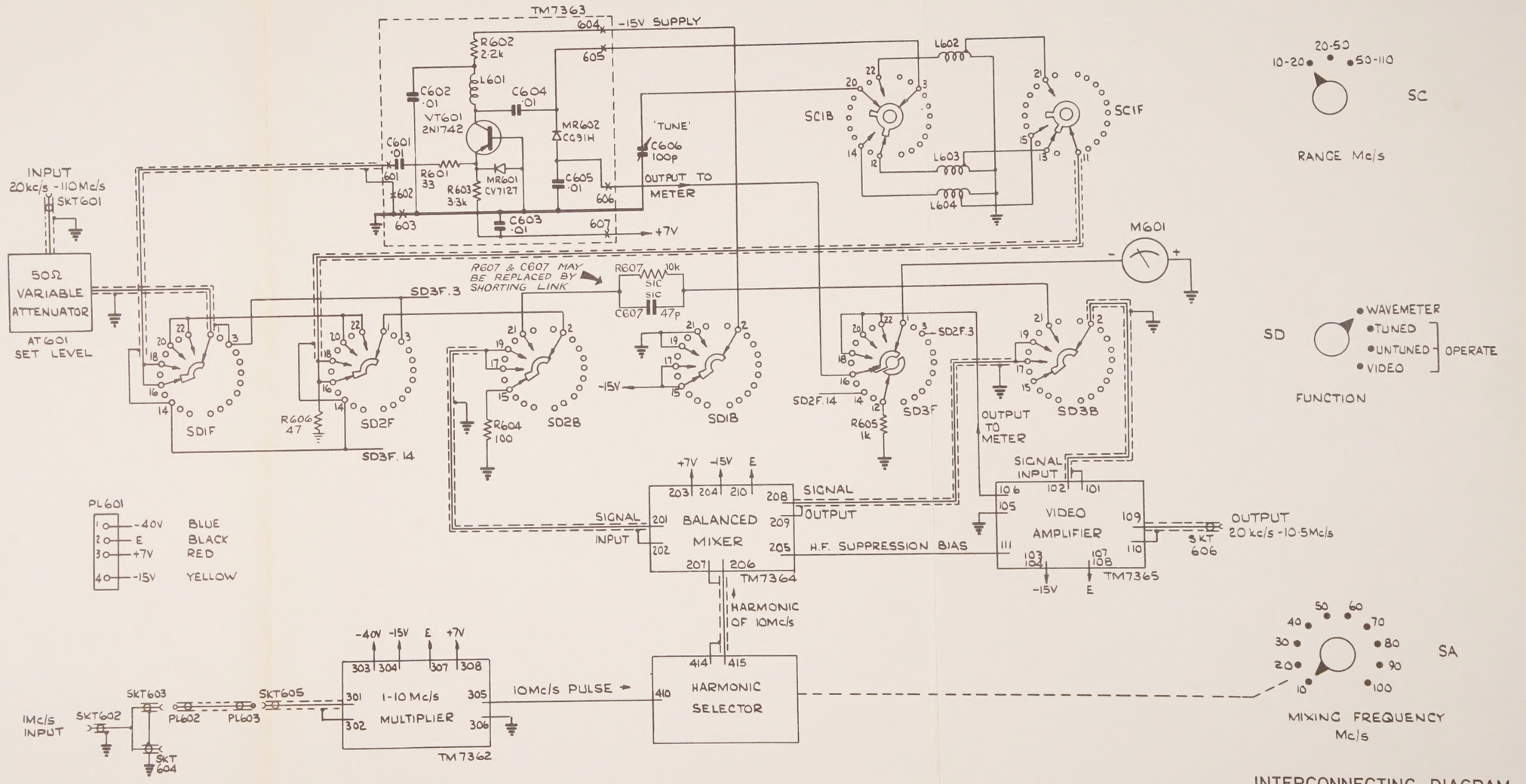
See introduction to this section for symbols and abbreviations

NOTES

1. COMPONENT VALUES
   Resistors : No suffix = ohms. k = kilohms. M = megohms.
   Capacitors : No suffix = microfarads. p = picofarads.
   SIC : value selected during test; nominal value shown.

2. SYMBOLS
   arrow indicates clockwise rotation of knob.

3. ROTARY SWITCHES
   Drawn as viewed from knob end with knob fully counter-clockwise.
   1F = 1st section, front
   1B = 1st section, back
   2F = 2nd section, front
   etc.



2400 (1a)

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